OMB Number: 4040-0004
Expiration Date: 10/31/2019

Application for Federal Assistance SF-424

* 1. Type of Submission:
- [ ] Preapplication
- [ ] Application
- [x] Changed/Corrected Application

* 2. Type of Application:
- [x] New
- [ ] Continuation
- [ ] Revision

* If Revision, select appropriate letter(s):

* Other (Specify):

* 3. Date Received: 03/02/2017

4. Applicant Identifier:

5a. Federal Entity Identifier: GRANT12356487

5b. Federal Award Identifier:

State Use Only:

6. Date Received by State:

7. State Application Identifier:

8. APPLICANT INFORMATION:

* a. Legal Name: University of North Carolina at Chapel Hill

* b. Employer/Taxpayer Identification Number (EIN/TIN): 566001393

* c. Organizational DUNS: 608195277

d. Address:

* Street1: 104 Airport Drive, Suite 2200, CB 1350
Street2:
* City: Chapel Hill
County/Parish: Orange
* State: NC: North Carolina
Province:
* Country: USA: UNITED STATES
* Zip / Postal Code: 27599-1350

e. Organizational Unit:

Department Name: Office of Sponsored Research

Division Name:

f. Name and contact information of person to be contacted on matters involving this application:

Prefix:
* First Name: Kati
Middle Name:
* Last Name: Chipps
Suffix:

Title: Grants and Contracts Specialist

Organizational Affiliation: University of North Carolina at Chapel Hill

* Telephone Number: 919-962-4665
Fax Number:

* Email: kati_chipps@unc.edu

Application for Federal Assistance SF-424

*** 9. Type of Applicant 1: Select Applicant Type:**

H: Public/State Controlled Institution of Higher Education

Type of Applicant 2: Select Applicant Type:

Type of Applicant 3: Select Applicant Type:

* Other (specify):

*** 10. Name of Federal Agency:**

Environmental Protection Agency

11. Catalog of Federal Domestic Assistance Number:

66.509

CFDA Title:

Science To Achieve Results (STAR) Research Program

*** 12. Funding Opportunity Number:**

EPA-G2017-STAR-D1

* Title:

Using a Total Environment Framework (Built, Natural, Social Environments) to Assess Life-long Health Effects of Chemical Exposures

13. Competition Identification Number:

NONE

Title:

None

14. Areas Affected by Project (Cities, Counties, States, etc.):

Add Attachment | Delete Attachment | View Attachment

*** 15. Descriptive Title of Applicant's Project:**

Building US Water Infrastructure to Improve Childhood Outcomes Interventions to Decrease Childhood Lead Exposure from Private Wells

Attach supporting documents as specified in agency instructions.

Add Attachments | Delete Attachments | View Attachments

Application for Federal Assistance SF-424

16. Congressional Districts Of:

* a. Applicant: NC-004 * b. Program/Project: NC-004

Attach an additional list of Program/Project Congressional Districts if needed.

Add Attachment | Delete Attachment | View Attachment

17. Proposed Project:

* a. Start Date: 09/01/2017 * b. End Date: 08/31/2019

18. Estimated Funding ($):

* a. Federal	800,000.00
* b. Applicant	0.00
* c. State	0.00
* d. Local	0.00
* e. Other	0.00
* f. Program Income	0.00
* g. TOTAL	800,000.00

*** 19. Is Application Subject to Review By State Under Executive Order 12372 Process?**

☐ a. This application was made available to the State under the Executive Order 12372 Process for review on .

☐ b. Program is subject to E.O. 12372 but has not been selected by the State for review.

☒ c. Program is not covered by E.O. 12372.

*** 20. Is the Applicant Delinquent On Any Federal Debt? (If "Yes," provide explanation in attachment.)**

☐ Yes ☒ No

If "Yes", provide explanation and attach

Add Attachment | Delete Attachment | View Attachment

21. *By signing this application, I certify (1) to the statements contained in the list of certifications and (2) that the statements herein are true, complete and accurate to the best of my knowledge. I also provide the required assurances** and agree to comply with any resulting terms if I accept an award. I am aware that any false, fictitious, or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties. (U.S. Code, Title 218, Section 1001)**

☒ ** I AGREE

** The list of certifications and assurances, or an internet site where you may obtain this list, is contained in the announcement or agency specific instructions.

Authorized Representative:

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Middle Name: R

* Last Name: Magnuson

Suffix:

* Title: Vice Chancellor for Research

* Telephone Number: (919) 966-3411 Fax Number: (919) 962-5011

* Email: resadminosr@unc.edu

* Signature of Authorized Representative: Terry Magnuson * Date Signed: 03/02/2017

OMB Number: 2030-0020
Expiration Date: 06/30/2017

EPA KEY CONTACTS FORM

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Title: Vice Chancellor for Research

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Payee: *Individual authorized to accept payments.*

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Zip / Postal Code: 27599 | **Country:** USA: UNITED STATES
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Administrative Contact: *Individual from Sponsored Programs Office to contact concerning administrative matters (i.e., indirect cost rate computation, rebudgeting requests etc).*

Name: **Prefix:** | **First Name:** Kati | **Middle Name:**
Last Name: Chipps | **Suffix:**
Title: Grants and Contracts Specialist

Complete Address:

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Street2:
City: Chapel Hill | **State:** NC: North Carolina
Zip / Postal Code: 27599-1350 | **Country:** USA: UNITED STATES
Phone Number: 919-962-4665 | **Fax Number:**
E-mail Address: kati_chipps@unc.edu

EPA KEY CONTACTS FORM

Project Manager: *Individual responsible for the technical completion of the proposed work.*

Name: **Prefix:** | **First Name:** Jacqueline | **Middle Name:**

Last Name: MacDonald Gibson | **Suffix:**

Title: Associate Professor

Complete Address:

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City: Chapel Hill | **State:** NC: North Carolina

Zip / Postal Code: 27599-7431 | **Country:** USA: UNITED STATES

Phone Number: 919-966-7892 | **Fax Number:** 919-966-7911

E-mail Address: jackie.macdonald@unc.edu

Table of Contents

Abstract

Funding Opportunity: Using a Total Environment Framework (Built, Natural, Social Environments) to Assess Life-long Health Effects of Chemical Exposures, EPA-G2017-STAR-D1

Title: Building Water Infrastructure to Improve Childhood Outcomes: Interventions to Decrease Childhood Lead Exposure from Private Wells

Investigators: Lead PI, Jacqueline MacDonald Gibson (www.unc.edu/~macdonaj/index.html); co-PIs: Keith Levine, John M. MacDonald, Philip J. Cook, Wandi Bruine de Bruin, Michael Fisher

Institutions: University of North Carolina, Chapel Hill, NC (Gibson and Fisher); Research Triangle Institute, Durham, NC (Levine); University of Pennsylvania, Philadelphia, PA (MacDonald); Duke University, Durham, NC (Cook); University of Leeds, United Kingdom (Bruine de Bruin)

Project Period: September 1, 2017 – August 31, 2019

Objectives and Hypotheses: While the recent Flint water crisis highlighted lead exposure risks in poorly managed municipal water supplies, little is known about lead in unregulated private wells. Our preliminary data from Wake County, NC, suggest that lead prevalence in peri-urban private wells could be comparable to that in Flint during the water crisis, with 28% of households exceeding the 15-ppb EPA action level. This project will be the first to estimate how lead in well water affects children's developmental outcomes. In addition, it will be the first to assess the association between lead in private well water and children's blood lead. The interacting influences of the built (availability of regulated water service), natural (groundwater chemistry), and social (household and school settings) environments on lead exposure and children's outcomes will be assessed. In addition, behavioral and technical interventions will be evaluated. We propose two overarching hypotheses. First, lead exposure in peri-urban NC communities drawing their water from unregulated wells exceeds that in neighborhoods with regulated water supplies. Second, this increased lead exposure decreases end-of-grade test scores and increases juvenile delinquency rates.

Experimental Approach: To characterize effects of lead in private well water on childhood developmental outcomes, children's end-of-grade test results for 1995-2016 will be extracted from the NC Education Research Data Center and merged with blood lead measurements from NC LEAD, juvenile records from the NC Department of Juvenile Justice and Delinquency Prevention, and household drinking water source (private well or regulated utility) records from the Wake County Division of Revenue. The merged data will be analyzed using established (multi-level regression) and novel (Bayesian network) methods to characterize total environmental effects on lead exposure, educational, and juvenile delinquency outcomes. To assess associations between lead in private well water and children's blood lead, we will analyze lead in tap water, dust, and paint in 300 randomly selected peri-urban private well households in Wake County, NC. In each household, blood and plasma lead will be measured in one child under age 6. Regression and Bayesian network approaches will be used to analyze associations between water lead and child's blood lead and interactions with characteristics of the built, natural, and social environments. A risk communication intervention to help prevent lead exposure will be developed and tested via a randomized controlled trial. An analysis of the costs and benefits of infrastructure and other technical interventions appropriate for different contexts will be prepared and disseminated to state and local health agencies.

Expected Results: We will provide quantitative estimates of risks to children arising from lead exposure in private wells and approaches for mitigating those risks under different built, natural, and social environment conditions.

Building Water Infrastructure to Improve Childhood Outcomes

Interventions to Decrease Childhood Lead Exposure from Private Wells

Background and Objectives

Background

The recent Flint, Michigan, water crisis focused national attention on the risks of exposure to lead in drinking water. In Flint, a change to a new, highly corrosive water source intended to save money for the bankrupt city unintentionally released lead from aging pipes into the water of tens of thousands of households.[1,2] Subsequent research documented that the prevalence of elevated blood lead in children more than doubled as a result.[2] In neighborhoods with the highest lead prevalence in tap water, the proportion of children with elevated blood lead increased from 4.0% to 10.6%.[2] Increased lead exposure is of critical public health concern due to the well-established associations between lead and impaired cognitive development. Numerous studies have found that environmental lead, even at low levels, is associated with decreased IQ, poor performance in school, and increased juvenile delinquency.[3–8]

While the Flint water crisis drew attention to lead exposure from mismanagement of a regulated municipal water supply, recent published and preliminary data from the principal investigator of this proposed project (Dr. Gibson) suggest that *lack* of access to a regulated water supply—the mirror image of the Flint situation—also could increase lead exposure via drinking water. Specifically, her research has focused on municipal water infrastructure access in peri-urban North Carolina (NC) neighborhoods. In some such areas, households rely on unregulated private wells, despite their close proximity to municipal water lines. **Figure 1** illustrates one of the neighborhoods Dr. Gibson has studied: households on the green-colored parcels draw their water from backyard wells, even though municipal water mains (in blue) skirt the neighborhood boundaries. Dr. Gibson's published research has documented a significant association between access to municipal water supplies in such areas and exposure to microbial drinking water contaminants, leading to increased risks of emergency department visits for acute gastrointestinal illness.[9]

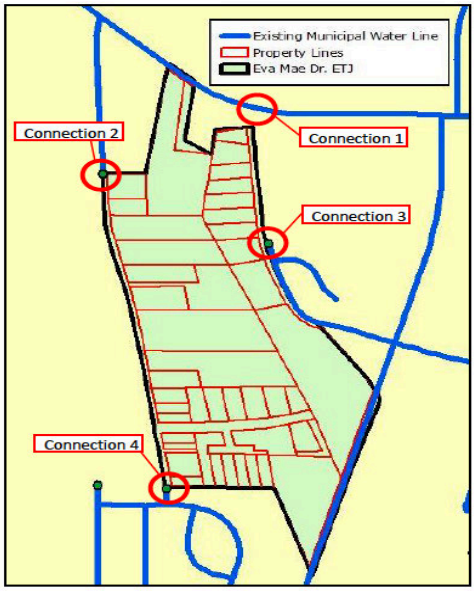

Figure 1. *The peri-urban Wake County, NC, neighborhood shaded in green lacks connections to the water mains, shown in blue, that surround it. The "connection" labels illustrate locations where the water mains could be tapped to serve this community. Households in this community obtain their water from unregulated backyard wells.*

Dr. Gibson's research has demonstrated that lack of access to nearby municipal water infrastructure disproportionality affects African Americans. This burden may be a legacy of legally sanctioned racial segregation—a phenomenon known as "municipal underbounding" that has been well documented by demographers.[10,11] (See the letter of support from Dr. Jeffrey P. Engel, former NC Director of Public Health, current Executive Director, Council of State and Territorial Epidemiologists.) As an example, **Figure 2** illustrates the role of race in water infrastructure access in the 1,567 peri-urban census blocks (population 89,600) in Wake County, NC.

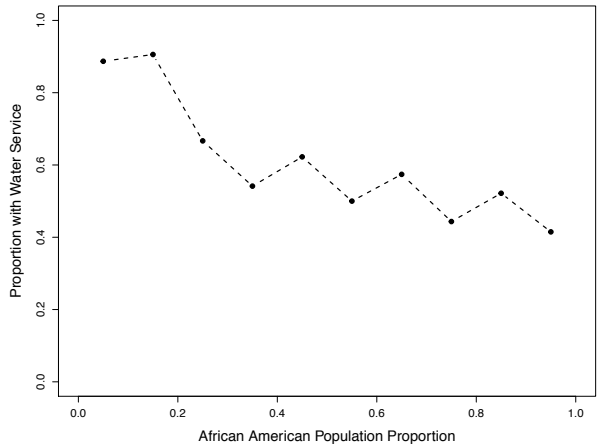

Figure 2. *The PI's prior published research documented that peri-urban African American neighborhoods like that in Fig. 1 are significantly less likely to have municipal water infrastructure than comparable non-African American neighborhoods.*[9]

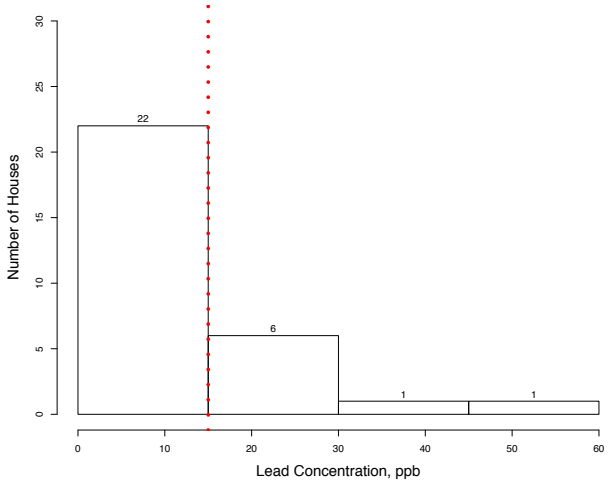

Figure 3. *Our preliminary data from 29 homes in peri-urban African American communities like that in Fig. 1 found that 28% had tap water exceeding the EPA action level of 15 ppb—a prevalence similar to that in Flint during the recent water crisis.*

Dr. Gibson's new preliminary data suggest a high risk of exposure to lead in drinking water in peri-urban African American neighborhoods lacking connections to nearby municipal water systems. **Figure 3** shows that among 29 households sampled, 8 (28%) had water lead levels at the kitchen tap above the 15-ppb Environmental Protection Agency (EPA) action level. This prevalence is comparable to that observed in Flint during the water crisis, where 28-32% of homes had lead levels above 15 ppb. These preliminary data, plus Dr. Gibson's previously published research, suggest that lead exposure is part of a larger set of toxins in the drinking water for this population.[12]

How This Research Advances Scientific Understanding

In this project, we propose to

- conduct the first research to characterize lead exposure in drinking water in peri-urban neighborhoods lacking access to nearby municipal water infrastructure;
- conduct the first analysis of associations between tap water lead and children's blood lead in households relying on private wells;
- for the first time, analyze associations between lead in children's drinking water and their end-of-grade test results, retention in grade, learning disabilities, and juvenile delinquency;
- develop and test in a randomized controlled trial the first evidence-based risk communication encouraging private well owners to test their water for lead and other contaminants; and
- prepare a comprehensive assessment and report of technical interventions for decreasing lead exposure in US peri-urban areas without access to municipal water infrastructure.

Although we focus on NC, our results will be relevant to peri-urban communities in other states. For example, recent research has revealed disparities in water infrastructure access in the Texas Lower Rio Grande River Valley[13] and in California's Central Valley.[14,15] Furthermore, many of the results will apply more broadly to rural households with unregulated wells. In the US, 14% of

the population relies on private wells.[16] Among US states, NC has the third-highest private well reliance (35%), behind Maine and Alaska.[17] As a result, NC is a suitable test bed for evaluating children's exposure to lead from private wells and solutions to prevent exposure.

How This Research Employs a Total Environment Framework (Built, Natural, and Social) to Assess Lifelong Health Effects of Children's Lead Exposure

This research is designed to uncover how the total environment—built, natural, and social—affects children's exposure to lead in drinking water (**Figure 4**). The main focus will be on the built environment—specifically the impacts of access to municipal water infrastructure on children's health, educational performance, and behavior. However, we will also evaluate whether the natural environment—specifically, groundwater chemistry—mediates the risk of lead exposure through its effects on corrosion of well components and plumbing. Similarly, our research will consider social factors—including parents' education, socioeconomic status, and the child's home and school environments. Our use of a quasi-experimental design and a Bayesian network modelling approach will enable the proposed research to characterize the effects of municipal infrastructure access, in combination with characteristics of groundwater and the school and home environments, on children's educational and behavioral outcomes. In addition to assessing the combined impacts of these factors, the project will evaluate policy interventions ranging from the distribution of risk communication materials to support for point-of-use treatment and/or extension of municipal water supplies.

A Multidisciplinary Team

The request for proposals indicates, "proposals that integrate a diverse field of disciplines . . . are highly recommended." Accordingly, the project team unites scientists from diverse backgrounds in order to confront the difficult challenge of understanding the effects of the total environment on lead exposure in communities without access to a regulated water supply and interventions to prevent those exposures. The team includes environmental engineers (Jacqueline MacDonald Gibson and Michael Fisher), an economist (Philip J. Cook), a criminologist (John MacDonald), an analytical chemist (Keith Levine), and a behavioral psychologist (Wändi Bruine de Bruin).

Gibson and Fisher have experience in field research linking environmental exposures to health outcomes. Gibson was PI on 628-household field study of associations between built environment

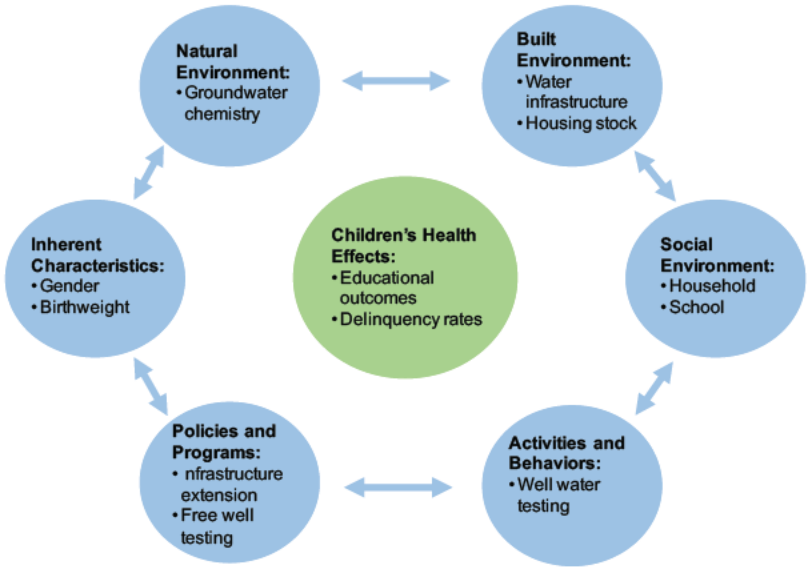

Figure 4. *This research will evaluate the effects of the built, natural, and social environments on the risks of exposure to lead in drinking water in peri-urban NC communities unserved by municipal water infrastructure.*

factors and public health in the United Arab Emirates. Fisher has led field research to characterize benefits of at-house water supply in Ghana, Ethiopia, and Sierra Leone. Economist Cook, a National Academy of Medicine member, is an expert on social factors influencing childhood outcomes, including education and juvenile delinquency.[18] Criminologist MacDonald brings expertise in how the built environment affects criminal behaviors. Analytical chemist Levine leads a Research Triangle Institute (RTI) team that develops and implements analytical methods for the determination of metals in support of environmental, pharmaceutical, and health-related projects. Behavioral psychologist Bruine de Bruin is a leading authority on designing and testing evidence-based risk communication interventions in health and environmental contexts. This diverse team has the experience and skills to uncover how access to municipal water infrastructure, in concert with groundwater characteristics and the neighborhood and school environments, affects children's educational performance and risk for delinquency through the effects of infrastructure access on lead exposure.

Objectives

The proposed project has five objectives:

1. **Characterize the effects of exclusion from municipal water infrastructure on children's blood lead, end-of-grade test results, retention in grade, learning disabilities, and juvenile delinquency.** Individual-level school records from the NC Education Research Data Center and juvenile complaints from the NC Department of Juvenile Justice and Delinquency Prevention (NCDJJDP) for 1995-2016 will be matched to peri-urban households with and without municipal water service. Childhood blood lead levels reported to the NC Division of Public Health for the same time period will be linked to the education and delinquency data. The result will be a merged data set at the level of individual children indicating whether the child has municipal water infrastructure at home, their blood lead level, their educational outcomes, and any juvenile complaint records. Multi-stage regression and Bayesian network models will be used to assess whether access to municipal water infrastructure is causally associated with childhood blood lead and, in turn, educational and delinquency outcomes.

   Hypothesis: Children without municipal water infrastructure will show decreased educational performance and increased delinquency risk, in comparison to those with municipal infrastructure who are similarly situated on poverty, household size, and other covariates.

2. **Characterize the relationship between lead in private well water and children's blood lead.** To examine the effect of lead in private well water on blood lead, kitchen tap water samples in 300 households in peri-urban neighborhoods relying on private wells will be tested for lead using ICP-MS. Homes will be recruited from the PI's existing database of peri-urban households without municipal water service by mailing recruitment letters (approximately 3,500 households) and following up with phone calls. Blood samples will be collected from one child under age 6 per household by a trained nurse. Lead in dust and paint in each household will also be tested.

   Hypothesis: Child blood lead levels will increase significantly with increases in lead in the household tap water.

3. **Characterize lead sources in water in private well households with elevated lead concentrations, in order to support the development of technical interventions**. A previously developed lead profiling technique involving sequential sampling will be used to characterize lead sources in 20 private well households testing positive for lead.[19] The analysis also will distinguish between particulate and dissolved lead. Most likely sources include well components, the well

discharge pipe, and/or indoor plumbing. The lead source determines the effectiveness and extent of flushing required to reduce exposure. Point-of-use treatment options will be recommended for cases where flushing is ineffective.

Hypothesis 1: Tap water flushing will reduce lead to below 15 ppb for most homes.

***Hypothesis 2*:** In a subset of homes, tap water flushing will increase the risk of lead exposure due to mobilization of particulate lead and lead sources upstream of the home plumbing.

4. **Conduct a randomized controlled trial of a behavioral intervention to promote testing of private well water for lead and other contaminants.** A risk communication intervention to encourage private well owners to test their water for lead and other contaminants will be developed and evaluated using the mental models approach.[20–22] In the mental models approach, risk communications are based on evidence about the relevant beliefs that the target audience already has (their "mental models") and what they are still missing. This method has proven effective in promoting behavior change in multiple health and environmental domains, from promoting safe sex to encouraging homeowners to test for radon in indoor air. The NC Division of Public Health will collaborate in this effort (see attached support letter from Dr. Mina Shehee, Head, Occupational and Environmental Epidemiology Branch, NC Division of Public Health).

   ***Hypothesis*:** Households receiving mental models-based risk communication materials will be more likely to test their water for lead and take action to prevent lead exposure than households in no-intervention control groups.

5. **Prepare a report evaluating and comparing technical interventions to decrease lead exposure in private well water in different contexts.** Four different technical interventions will be evaluated and compared: tap water flushing before consumption, purchase of bottled water, household water treatment, and extension of municipal water infrastructure. Using results from this study along with preliminary engineering analyses and a literature review, costs of these alternatives along with their benefits in terms of improved childhood outcomes will be compared for a selected sample of peri-urban Wake County neighborhoods. On the basis of this review, a report will be prepared recommending interventions to prevent childhood lead exposure from private well water under different scenarios of well type, groundwater characteristics, household characteristics, and proximity to municipal water infrastructure.

Approach/Activities

Objective 1: Merge Existing Databases to Assess Water Infrastructure Effects on Lead Exposure and Children's Outcomes

Approach Overview

No prior research has evaluated whether access to regulated municipal water infrastructure affects children's educational or behavioral outcomes as mediated by exposure to lead. In order to explore causal associations among water infrastructure, lead exposure, and childhood outcomes, we will prepare a merged database of drinking water sources, children's blood lead levels, school end-of-grade test results and other educational outcomes, and juvenile complaints using existing information repositories in multiple NC agencies. The database observations (rows) will be at the level of individual children. No existing, similar database exists. Our team is uniquely positioned to create such a database due to our established relationships with the relevant state and nonprofit agencies maintaining the required data (see support letters). In addition, we have prior experience in creating and

analyzing similar, merged data sets (see, for example, the recent paper by Cook and Kang).[18] In total, we anticipate that the merged database will contain records for about 15,000 children, providing a very large sample size for assessment of causal associations.

On the basis of our preliminary data (**Figure 3**), we posit that access or lack of access to a regulated municipal water system influences the lead concentration in children's household drinking water. In turn, based on others' prior research linking lead exposure in municipal water to blood lead,[23–25] we expect that lead in private well water will affect blood lead during a child's key developmental years. Substantial prior research by others suggests that differential blood lead concentrations during formative ages will in turn affect educational performance and juvenile delinquency risk in later childhood.[4–8,26,27] **Figure 5** illustrates the posited causal chain linking lack of municipal water infrastructure to children's educational and behavioral outcomes. We will be the first to examine this chain in its entirety. Using the merged data set, two-stage least-squared regression and Bayesian network models will be constructed to explore the relationships in Figure 5.

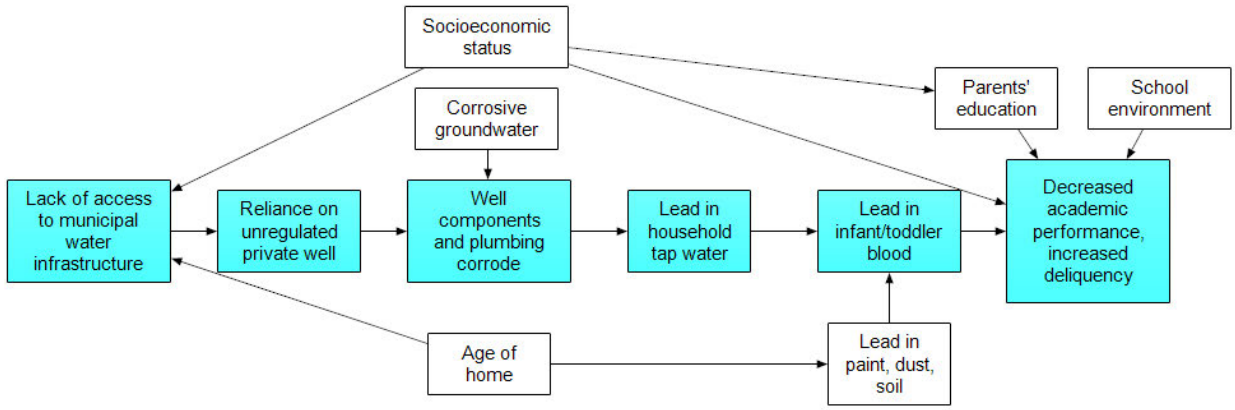

Figure 5. *Postulated causal chain (in blue) linking lack of access to municipal water infrastructure to lead in children's blood and associated adverse developmental outcomes.*

Data Sources

Access to Municipal Water Supplies

Wake County, NC, is an ideal setting to explore the causal chain in **Figure 5** because, unlike many other locales, tax records indicate water infrastructure access for each property parcel. The PI has previously used these property tax data to characterize relationships between race and water supply access, as shown in **Figure 2**.[9] Household-level data on water infrastructure availability in peri-urban neighborhoods will be obtained for each year from 1995 through 2016 from the Wake County Division of Revenue.[9] Households will be defined as "peri-urban" if they are located in a municipal extraterritorial jurisdiction (ETJ), defined by NC legislation as land over which the adjacent municipality retains zoning and land-use control while not being obligated to provide municipal services. Under NC General Status, Article 19, 160A-360, municipalities may claim extraterritorial jurisdiction over land up to three miles from the municipal border.[28] Residents in ETJs, unlike those within corporate limits, do not have rights to basic amenities or the right to vote in municipal elections, even though the municipal government can dictate land uses in their communities. Along with municipal water access data, house value, property value, and house age will be extracted for each ETJ parcel. These data will be used to control for average differences in housing stock and property value between peri-urban neighborhoods with and without municipal infrastructure. The total 2010 population of these peri-urban areas was 89,600—about 10% of the Wake County population.

Childhood Blood Lead Data

Each year, more than one-third of Wake County children ages 1-2 are screened for lead, and the results are reported to the NC Childhood Lead Poisoning Prevention Program. This program has agreed to provide individual-level blood lead analysis results for all children tested in Wake County since 1995 (see attached support letter from Ed Norman, Head, Children's Environmental Health Unit, NCDPH). Names, home addresses, birth dates, blood lead test dates, and type of blood test (venous or capillary) for each child tested in Wake County will be provided. The number of children screened per year has steadily increased; in 2014, 10,500 were tested. Based on the total number of children tested per year and the time span of data collection, we expect to receive more than 150,000 records. From these records, we will extract test results for children living in peri-urban neighborhoods (those located in municipal extraterritorial jurisdictions, as defined above). Given that the population of interest accounts for about 10% of the county population, we expect that more than 15,000 childhood blood lead records will be available for the target populations in this analysis.

Educational Outcomes Data

End-of-grade (EOG) reading and math test results for those among the 15,000 children in the target population with blood lead records who have completed at least third grade will be extracted from the NCERDC. In addition, "retained in grade" and "exceptionality status" (indicators of learning disabilities) will be extracted. Key covariates, including race, parents' level of education and economic status, school, test date, and age on test date, will be extracted. EOG test records will be matched to blood lead test results and household locations using multiple search strategies, including multiple combinations of social security number, last and first name, data of birth, home address, and county federal information processing standards code. Data extraction will be performed by NCERDC (see attached support letter from Dr. Clara Muschkin, NCERDC Director).

Juvenile Delinquency Data

Juvenile complaints for all juveniles living in the extraterritorial jurisdiction households will be extracted from the NCDJJDP for the years 1995-2016 (see, for example, prior publications by co-PI Dr. Philip J. Cook).[18]

Merged Database

A merged database with drinking water source (private well or regulated system); blood lead level; household, family, neighborhood, and school characteristics; educational outcomes (EOG scores, retained in grade, and exceptionality status); and juvenile delinquency complaints for the approximately 15,000 children in peri-urban areas tested for lead between 1995 and 2016 will be prepared.

Statistical Analysis Methods

The merged data set will be used to analyze the effects of municipal water infrastructure, lead exposure, and household, neighborhood, and school characteristics on multiple outcomes. Outcomes will include EOG results, advancement to the next grade, learning disabilities, and juvenile delinquency. Two statistical constructs will be developed and compared: two-stage least-squares regression and Bayesian network models. Additional regression models will be explored as robustness checks.

Two-stage least-squares (TSLS) regression has become established as a method for estimating average "per-unit average causal effects along the length of an appropriately defined causal response function."[29] The colored nodes in **Figure 5** illustrate the causal response chain to be evaluated in this research. TSLS approximates an experiment for analyzing causal associations between water lead and children's outcomes as long as the instrument (access to a regulated water system) conditional on covariates is effectively independent of other factors.[29] For this research, the first stage of the TSLS regression will be formulated as

$$BLL = \delta_0 + \vec{X}_1\vec{\delta}_1 + \vec{X}_2\vec{\delta}_2 + \delta_3 W + \eta \quad (1)$$

where *BLL* is the child's blood lead level, $\boldsymbol{X_1}$ and $\boldsymbol{X_2}$ are covariate vectors, $\boldsymbol{\delta_1}$ and $\boldsymbol{\delta_2}$ are coefficient vectors, *W* is an indicator variable of household water source (private well or regulated system), δ_3 is a coefficient, and η is an error term. In the second stage, end-of-grade test score (reading or math for a given grade) will be regressed on the estimated *BLL* ($\widehat{BLL}$) and the $\boldsymbol{X_1}$ covariates:

$$EOG = \gamma_0 + \vec{X}_1\vec{\gamma}_1 + \rho\widehat{BLL} + \nu \quad (2)$$

where $\nu \equiv \varepsilon + \rho[BLL - \widehat{BLL}]$. In this formulation, $\rho\delta_3$ represents the effect of having municipal water service on children's educational performance or juvenile delinquency through its effects on blood lead. All TSLS analyses will be conducted using the *tsls* function in the **sem** package of *R*.

To provide additional insights on interacting effects among built, natural, and social environmental variables, we will construct Bayesian network models. A Bayesian network is a graphical representation of the variables in a system of interest, linked by probabilities. Variables are represented by nodes in the network (for example, the boxes in **Figure 5**), and relationships among variables by edges (the arrows in **Figure 5**). The joint probability distribution of all of the variables can be expressed as the product of conditional probability distributions representing relationships between "child" nodes (X_i) and their parents (PA_i) (those with arrows pointing directly to the child):

$$P(x_1, .., x_n) = \prod_{i=1}^{n} P(x_i \,|pa_i) \quad (3)$$

Since Judea Pearl developed the first algorithm for solving these networks,[30,31] they have been increasingly used to support causal inference in a variety of application areas, for example in medical diagnostics.[32,33] They can be advantageous over regression approaches in causal inference assessment due to their ability to handle missing data and to include collinear variables.

Bayesian network models will be constructed using *BayesiaLab* (Change, France). Network structures and joint probability tables will be learned from the merged data set using multiple algorithms (e.g., naïve Bayes, Markov blanket) in *BayesiaLab*, and the structure that best fits the data set will be selected. The performance of the regression and optimal Bayesian network models in predicting educational outcomes and juvenile delinquency will be compared via cross validation, similar to our prior research.[34] The Bayesian network models are expected to yield additional insights about how interactions among built, natural, and social environmental factors, along with individual characteristics, could influence the educational and behavioral outcomes considered in this research.

Objective 2: Characterize the Relationship Between Lead in Well Water and Blood Lead

Approach Overview

To our knowledge, only six previous studies in North America have investigated associations between water lead and children's blood lead.[25] In all six studies, all of the children lived in households with municipal water infrastructure.

In this study, lead exposure and blood and plasma lead will be measured for one child under age 6 in 300 peri-urban households relying on private wells recruited from Dr. Gibson's existing database of 3,500 households (e.g., **Figure 6**). The data collection protocol will build on that of Ngueta et al. (2016), who found a significant positive association between water lead and children's blood lead in Montreal, Canada, neighborhoods with aging municipal water infrastructure.[25,35] Our research differs from that of Ngueta et al. in focusing on private wells.

All chemical analyses will be conducted by a team of 50 experienced analytical chemists in the laboratories of RTI International, located in the Research Triangle Park, NC. In addition to holding a current North Carolina Wastewater/Groundwater Certification that includes lead and 27 other in-

organic analytes, RTI has processed tens of thousands of biological samples for both public and private sector clients, including many projects that have been subject to regulatory compliance.

Figure 6. *Dr. Gibson and doctoral student Frank Stillo inspect a private well in a peri-urban household in Wake County, NC, during a previous field sampling campaign.*

Household Water and Blood Sampling

Participant Recruitment

Recruitment letters with consent forms will be mailed to the 3,500 households in municipal extraterritorial jurisdictions of Wake County relying on private wells. Research staff will follow up with phone calls to request participation and determine eligibility. The first 300 households agreeing to participate and matching the inclusion criteria will be enrolled. Each household will be offered a $75 gift card for participation, in addition to free water testing.

Inclusion Criteria

To be included in the study, households must obtain their drinking water from a private well, not use an acid neutralizer or reverse-osmosis water treatment system, live in a structure with no more than two units, have lived at their current residence for at least one year, and have a healthy child between the ages of 1 and 6 who was born in the United States, regularly drinks the tap water, and does not regularly spend more than two days per week away from home.

Water Sample Collection

Research staff will deliver pre-acidified 1-L sample bottles to each household with instructions for collecting a first-draw morning sample from the kitchen tap after an overnight stagnation period. On the day of the morning sample collection, staff will visit the home and collect samples according to the protocol of Ngueta et al.[25] First, a 1-L kitchen tap sample will be collected after five minutes of flushing. After 30 minutes of stagnation, four consecutive 1-L samples will be collected. All samples will be drawn at normal flow rates (5-7 L/minute) without removing the tap aerator. Staff will measure flow rate, temperature, pH, conductivity, and alkalinity using portable instruments.

Water Sample Analysis

RTI will measure lead and other elements of interest via ICP-MS using EPA Method 200.8.

Household Environment Lead Sampling

During the initial home visit, samples of household dust and paint will be collected using the protocol described in Levallois et al.[36] RTI will analyze the samples using the procedures developed to support the American Industrial Hygiene Association's environmental lead program.

Blood Sample Collection

Venous blood samples will be collected by a registered nurse hired through the UNC Clinical and Translational Research Center. Briefly, participants will be asked to report to a central location near their home during the week in which their household water is being tested. After the child is weighed, one blood sample will be collected in a Becton-Dickinson tube pretreated with EDTA and maintained at 4°C until analysis by RTI.

Blood and Plasma Analysis

Blood and plasma will be analyzed for lead and other elements of potential interest, including arsenic, cadmium, chromium, copper, iron, manganese, molybdenum, nickel, selenium, and zinc using RTI's published laboratory procedures.[37] Laboratory quality control samples (QC) will be processed with each batch of study samples to ensure data quality. These QC samples will include method blanks to monitor the analyte contribution from the reagents and procedure, analyte-fortified matrix samples to monitor recovery and instrument stability, incurred sample reanalysis to monitor precision, and standard reference materials from the National Institute of Standards and Technology.

Household Questionnaire

A household questionnaire will be administered to an adult caretaker at the time of water sample collection. The questionnaire will ask about the child's day care attendance, duration of breastfeeding, time lived in the present household, parents' education and employment, number of meals per day, activity patterns (e.g., locations of play), parents' occupational exposure to lead, household hobbies (such as paint stripping) potentially affecting lead exposure, child risk behaviors such as pica or licking or gnawing on household surfaces, smoking in the home, and frequency of home cleaning.

Statistical Analysis

For each child, a cumulative water lead exposure index (CWLEI) will be computed as described in Ngueta et al.[25] The CWLEI represents lead exposure via drinking water over the five months prior to blood sample collection; the five-month time interval is thought to represent the time to reach a steady-state concentration after repeated exposure. The child's blood lead and plasma lead concentrations will be regressed on CWLEI divided by body weight, controlling for additional covariates (including exposure via dust and paint). Statistical analyses will be performed in *R*.

Objective 3: Characterize Lead Sources in Private Well Households with High Water Lead

Approach Overview

Lead in private well water generally arises from corrosion of well components or indoor plumbing, or from mobilization of particulate lead from prior corrosion.[19] The EPA recommends that private well owners flush their tap for two minutes in order to remove corrosion products before drinking the water.[38] However, recent research has revealed that flushing is not always effective.[19] In some instances, flushing can *increase* lead exposure by mobilizing particulate lead. As a result, although flushing can be a low-cost intervention, understanding the sources of lead is critical for determining whether flushing will decrease lead exposure and, if so, the duration of flushing required. The 3-D lead profiling methods described by Pieper et al. (2017) will be adapted for this purpose.[39]

Sequential Sampling Method

Twenty households will be recruited for lead profiling through a random selection from those testing positive for lead in Objective 2. In each home, after a 6-h stagnation period, seven sequential 1-L samples will be collected at a low flow rate (~1.3 L/m), followed by three 250-mL flushed samples at 2-minute intervals. This sequence will be repeated at a moderate flow rate (4.2 L/min). Six sequential 1-L samples will then be collected at a high flow rate (~7.5 L/min), followed by six 250-mL flushed samples collected at 1-minute intervals. The household respondent will be asked to demonstrate the flow rate they typically use, and this flow rate will be measured. Finally, three sequential 1-L samples will be collected from outside of the home, either from the well (if accessible), or from an outdoor tap (if available) to differentiate between lead originating from indoor fixtures and from sources outside of the home. Collected water samples will be acidified and analyzed at RTI by ICP-

MS as described above. In addition to measuring dissolved lead, particulate lead will be distinguished by filtering sample aliquots prior to analysis using previously published methods.[40]

Analysis of Sequential Sampling Data

First-flush and steady-state lead exposure concentrations will be calculated for each household. On the basis of the household data, a Bayesian network model estimating the distribution of likely exposures for first-flush and steady-state conditions for households with different characteristics (well types, plumbing, groundwater quality) will be developed using *BayesiaLab* software. The network model will be used as the basis for assessing flushing as an intervention as part of Objective 5.

Objective 4: Conduct a Randomized Controlled Trial of a Behavioral Intervention to Promote Testing of Private Well Water

Approach Overview

Our recent semi-structured interviews with 18 households in peri-urban Wake County neighborhoods and our ongoing follow-up survey of 1,000 households have found few have tested their water for lead.[41] The structured interviews revealed that only 1 of 18 respondents was aware that the county health department recommends regular well water testing[41] (annually for bacteria, every two years for lead). Our preliminary survey results are confirming this low awareness of testing.

We will use the mental models approach to design and test risk communications to promote private well testing. No prior such communications have been developed. The mental models approach is based on the premise that "the provision of information should begin with an empirical evaluation of what people already know, along with a scientific determination of what missing information is most critical to their decisions."[42]

Risk Communication Design

The mental models approach uses four steps, shown in **Figure 7**. We have already completed the first step (developing an expert decision model) and most of the second step (identifying what people already know and how they make their decisions). For the second step, as previously mentioned, we conducted semi-structured interviews with 18 heads of household. We coded and analyzed the interviews to identify common beliefs and preferred language. We designed and (in January 2017) distributed a follow-up survey to 1,000 households. Step 3 (designing the risk communication) will be completed as part of this proposed research.

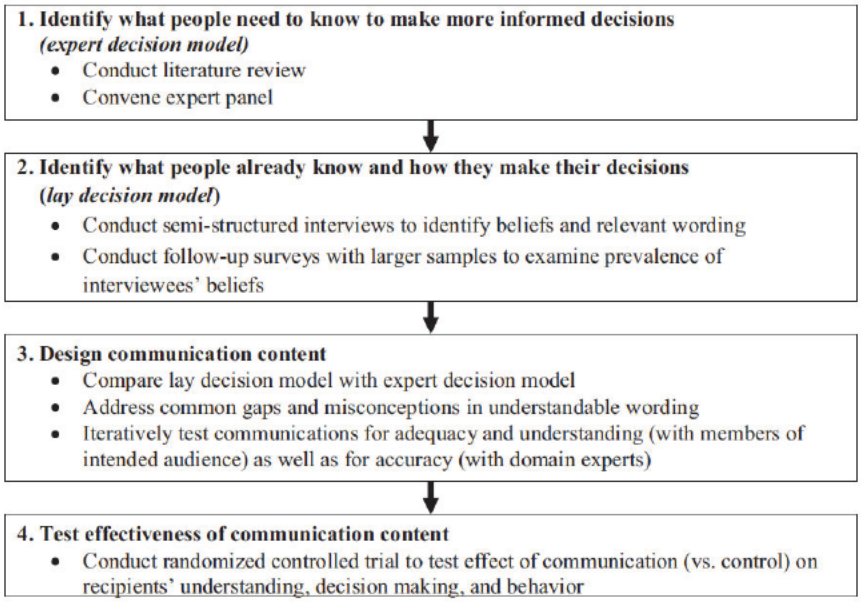

Figure 7. *Four steps in the mental models approach to risk communication (from Bruine de Bruin and Bostrom, 2013).*[21]

Table 1. Randomized Controlled Trial Design

Financial Intervention	Behavioral (Risk Communication) Intervention	
	No Risk Communication	Risk Communication
No Free Water Test	Group 1 (control), n=88	Group 2, n=88
Free Water Test	Group 3, n=88	Group 4, n=88

NOTE: n=88 in each cell assumes 10% survey response rate

Risk Communication Evaluation

We will use a randomized controlled trial to test whether the communication increases knowledge of private well testing guidelines, decisions to test the water, and decisions to take action if contamination is found. The structured interviews revealed not only that few people were aware of the need for regular testing of their water but also that cost is a barrier to testing in some cases. Therefore, our randomized controlled trial will test the influence of a financial intervention (free water testing), in addition to the risk communication intervention.

For the trial, we will randomly assign the 3,500 peri-urban households relying on private wells into four groups, shown in **Table 1**. One month after the free water testing and risk communication offers are distributed, a survey will be mailed to all households to inquire about their beliefs concerning water testing, whether they have tested their water, and whether they have acted to address any contaminants found. Assuming, conservatively, a 10% response rate, this design will detect a 5% increase in well testing with power > 80% at 5% significance (see power analysis in Quality Assurance Statement). A $25 gift card incentive will be offered to the first 200 respondents.

Objective 5. Prepare a Report of Technical Interventions to Decrease Lead Exposure in Private Well Water in Peri-Urban Areas

Approach Overview

Our preliminary data (**Figure 3**) suggest that we will find a high prevalence of lead in tap water in the peri-urban communities of this study. An analysis and report of technical options for preventing lead exposure will be essential to help affected households and government agencies take action where our research reveals elevated lead levels in drinking water. We will analyze and compare four technical options: tap water flushing, bottled water purchase, household water treatment, and extension of municipal water lines. The report will evaluate the benefits and drawbacks of each approach for different contexts (e.g., household characteristics such as age and plumbing type, well type, groundwater type, and proximity to municipal water infrastructure). In addition, costs and benefits in terms of prevented adverse health outcomes will be evaluated for four example peri-urban neighborhoods (such as the neighborhood in **Figure 1**).

Tap Water Flushing Evaluation and Guidelines

The results of Objective 3 (lead profiling) will be used to generate a Bayesian network for estimating whether flushing can decrease tap water lead and, if so, the required flushing time, given characteristics of the household plumbing, well, and groundwater chemistry. We will use the tool to prepare written recommendations for situations in which flushing is and is not likely to be effective.

Bottled Water, Household Water Treatment, and Municipal Infrastructure Comparison

Present-value costs of extending water infrastructure to four model peri-urban Wake County neighborhoods will be compared with costs of providing point-of-use treatment or bottled water to each household. The principal investigator already has prepared preliminary water infrastructure designs for four such neighborhoods (including the neighborhood in Figure 1). Network designs were created in WaterGEMS (Bentley, Exton, Pa.), and the capacity of the existing City of Raleigh network

to support the additional demand was estimated in collaboration with the City of Raleigh Public Utilities Department using the City of Raleigh Master Water Model. Construction cost estimates for these four designs will be estimated using bids for four recent water infrastructure projects provided by the Raleigh Public Utilities Department. These costs will be compared with the costs of supplying each household with whole-house and under-sink systems capable of lead removal, including costs of maintaining these systems and conducting annual water quality tests over a 20-year time horizon. Costs of providing bottled water over a 20-year time period also will be estimated.

Report of Interventions for Different Contexts

The project team will write and disseminate a report recommending interventions to prevent private well lead exposure in different built, natural, and social environment contexts.

Innovation

This study will be the first attempt to associate lead exposure via drinking water with children's educational and behavioral outcomes. In addition, it will be the first to assess associations between children's blood lead levels and lead in private well water. It will be the first to consider the effects of exclusion from municipal water infrastructure on lead exposure—the mirror image of the Flint water crisis. The research will provide the first mental models–based communication materials encouraging private well owners to test their water.

Expected Results, Benefits, Outputs, and Outcomes

This project will generate several first-of-a-kind scientific analyses:

- lead exposure in drinking water in peri-urban neighborhoods without municipal water infrastructure (effectively, the mirror image of Flint during the water crisis)
- associations between tap water lead and children's blood lead in households relying on private wells (whether rural or peri-urban)
- associations between lead in water and children's educational and behavioral outcomes

The project also will deliver practical results that policymakers can use to design interventions:

- evidence-based risk communications encouraging private well owners to test their water
- comprehensive assessment and report of technical interventions for decreasing lead exposure from private wells in a variety of contexts

Although the project focuses on NC, the results will be relevant to peri-urban communities without municipal water infrastructure in other states (for example, Texas and California). In addition, many key results (including the assessment of relationships between private well water lead and children's blood lead, the risk communications, and the evaluation of technical interventions) are expected to have broad relevance to the 14% of the US population relying on private wells for their water.

Project Management

Personnel Qualifications

PI Jacqueline MacDonald Gibson, Ph.D., will coordinate and lead the project. She is Associate Professor of Environmental Sciences and Engineering at the University of North Carolina (UNC),

Chapel Hill. She laid the groundwork for the proposed study by documenting racial disparities in municipal water infrastructure access in NC and resulting increases in acute gastrointestinal illness risks.[9,12] She has established community connections that will facilitate the recruitment of households for this study. She also brings substantial prior experience in leading large field research teams, including competitively awarded studies requiring data collection in 628 randomly selected households in the United Arab Emirates and 20 households in a low-income minority community in San Antonio, Texas.

Philip J. Cook, Ph.D., will lead the analysis of water infrastructure effects on educational outcomes (Objective 1). In addition, he will coordinate access to juvenile justice data through the NC Department of Juvenile Justice and Delinquency Prevention. Cook is ITT/Sanford Professor of Public Policy, and Professor of Economics and Sociology, at Duke University. He is a pioneer in the development and application of microeconometric methods to impact evaluation, and published the first use of "diff in diff" evaluations of policy change using panel regression methods. Dr. Cook was elected to the National Academy of Medicine in 2001.

John MacDonald, Ph.D., will lead the assessment of water infrastructure effects on juvenile delinquency (Objective 1). Dr. MacDonald is Professor of Criminology and Sociology at the University of Pennsylvania. Dr. MacDonald is recognized for his efforts to reduce violence, improve health, and enhance social justice. His work incorporates spatial and time series methods for evaluating the effect of changes to places or programs on people and populations. His work has been cited by major media outlets across the globe and appears in the leading peer reviewed journals in criminology, economics, public health, and statistics, including the *American Journal of Epidemiology, BMJ: Injury Prevention,* the *American Journal of Preventive Medicine,* and the *American Journal of Public Health.*

Dr. Keith Levine, Ph.D., will lead the analyses of water and blood samples (Objective 2). During his nearly 20-year tenure as a research chemist at RTI International, Dr. Levine's team has determined the concentrations of trace elements in tens of thousands of biological, environmental, and geological samples for public- and private-sector clients, yielding nearly 50 peer-reviewed publications. Dr. Levine's laboratory administers the Environmental Lead Proficiency Analytical Testing Program on behalf of the American Industrial Hygiene Association.

Michael Fisher, Ph.D., UNC post-doctoral associate, will oversee lead profiling (Objective 3), support Dr. Gibson in coordinating field collection of water and blood samples (Objective 2), and complete analysis of potential interventions (Objective 5). He has previously designed, conducted, and analyzed adequately powered field studies comparing water quality across source types and consumption patterns in rural, peri-urban, and urban settings in Ghana, Ethiopia, and Sierra Leone.

Wändi Bruine de Bruin, Ph.D., will oversee development and testing of the risk communications (Objective 4). She is University Leadership Chair in Behavioural Decision Making at Leeds University Business School, where she co-directs the interdisciplinary Centre for Decision Research. Her expertise includes behavioral decision making, risk perception and communication, and behavior change interventions. She has published in peer-reviewed journals in multiple disciplines, including psychology, environmental science, engineering, and public health. She serves on the editorial boards of the Journal of Behavioral Decision Making, Journal of Risk Research, Journal of Experimental Psychology: Applied, Medical Decision Making, and Psychology & Aging. She recently served on the National Academy of Sciences expert panel on the Science of Science Communication and the Council of Canadian Academies' panel on the effectiveness of health risk communications.

Facilities

This project will benefit from the combined facilities of the UNC Gillings School of Global Public Health and RTI International.

Data management and analysis will occur at UNC. Dr. Gibson's laboratory is equipped with encrypted, password-protected computers that are disconnected from the Internet for safe storage of human subjects data. She has previously used these resources for secure storage of her human subjects data from studies in NC, the United Arab Emirates, Texas, and elsewhere. These secure systems are maintained by the UNC Gillings School of Global Public Health Instructional and Information Systems department. Only Dr. Gibson and her designated, trained research assistants will have access to the encrypted computer. Data will be de-identified before sharing with the team.

Chemical analyses will occur at RTI. For more than 20 years, RTI has supported the Environmental Lead Proficiency Analytical Testing Program on behalf of the American Industrial Hygiene Association (http://www.aihapat.org/Programs/ELPAT/Pages/default.aspx). This program provides interested parties with objective evidence of a laboratory's capability to produce accurate, repeatable lead measurements in paint, soil, and dust. RTI prepares and analytically characterizes a minimum of 200 samples from each of the three matrices at each of four different concentrations on a quarterly basis. As the laboratory that helps other environmental laboratories demonstrate proficiency with environmental lead testing, RTI has processed tens of thousands of samples for lead content and is highly qualified to conduct these measurements in support of this investigation.

Project Schedule

	Year 1				Year 2			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Objective 1: Water infrastructure effects on children's educational, behavioral outcomes								
Compile merged database	x	x	x					
Fit statistical models to database				x	x	x	x	x
Objective 2: Water and blood lead analyses								
Recruit households			x					
Collect and analyze samples				x	x			
Fit statistical models to results						x	x	x
Objective 3: Lead source identification								
Recruit households					x			
Conduct profiling experiments; analyze samples						x		
Develop Bayesian network model to predict flushing effectiveness							x	x
Objective 4: Risk communication randomized trial								
Design communication	x							
Disseminate communication		x						
Collect data on behavior change			x					
Analyze effectiveness of communication				x	x	x		
Objective 5: Report of technical interventions								
Design interventions for case study neighborhoods, assess costs	x	x	x	x				
Prepare report including general guidelines							x	x

Overall Management Plan and Tracking of Project Progress

Dr. Gibson will be responsible for ensuring that all project objectives are successfully achieved within the grant period. The project team will meet monthly by Skype and yearly in person to chart progress. Administrative staff of the UNC Water Institute (http://waterinstitute.unc.edu/) will assist with project tracking to ensure that grant funds are expended in a timely and efficient manner. Since 2009, the Water Institute has managed more than 65 projects with more than 40 donors totaling $12 million.

Quality Assurance Statement

1. Identify the individual who will be responsible for the quality assurance (QA) and quality control (QC) aspects of the research. Dr. Gibson, project PI, will oversee QA/QC. Dr. Gibson has previous experience in such oversight roles. She was PI on a $12.9 million project funded by the Environment Agency-Abu Dhabi to characterize the environmental burden of disease across multiple media in the United Arab Emirates, leading a team of 88. The project included collection of indoor and outdoor environmental data and health questionnaires in 628 randomly selected households. In addition, she was PI for a project to collect indoor air samples and conduct health questionnaires in 20 low-income minority households in San Antonio, Texas, funded by the Passport Foundation. Funded by the National Science Foundation, she also led a survey research project involving 493 respondents in Monterrey, California. With support from the Robert Wood Johnson Foundation and IBM Junior Faculty Development Fund, she led tap water quality sampling in 57 homes relying on private wells in Wake County, NC. For each of these prior projects, she successfully managed all QA/QC procedures, from chain-of-custody requirements for collected samples to secure data storage to analysis and reporting.

2. Discuss project objectives, including quality objectives, any hypotheses to be tested, and the quantitative and/or qualitative procedures that will be used to evaluate the success of the project. Pages 4-5 of the research plan explain the project objectives and hypotheses. Quality objectives of this work include:

1. developing a written project quality assurance project plan (QAPP) in collaboration with the entire research team (and conforming to American National Standard ANSI/ASQC E4-1994) to enable the team to specify and track its quality objectives;
2. providing a Quality Management Plan (QMP) covering all collaborating institutions;
3. performing all work according to clear written standard operating procedures (SOPs), and making these SOPs available with results in all research publications, reports, and communications;
4. conducting analyses according to existing published standard methods wherever possible, and referencing these methods in all project documentation, reporting, publications, and SOPs;
5. regularly calibrating all instruments and equipment and/or preparing standard calibration curves according to the manufacturer's instructions using NIST-traceable standards (where available) with a frequency adequate to achieve data quality objectives (typically at least daily);
6. regularly conducting all required QA calibrations and data review activities, and regularly collecting all required QC sampling and analysis as per the QAPP;
7. collecting QC samples (field blanks, field duplicates, laboratory duplicates, blind standards, and matrix spikes, as appropriate) comprising at least 10% of all samples analyzed;
8. maintaining adequate accuracy, precision and completeness of all project data, as determined from review of laboratory notebooks and records, QA/QC sample results, and comparison of analysis records to sample collection records;
9. maintaining detailed documentation of all SOPs, methods, parameters, and analyses to enable the research methods and activities to be evaluated and/or reproduced as needed;
10. documenting chain of custody for all environmental samples and biospecimens; and
11. ensuring that required sample holding times and temperatures are not exceeded.

Dr. Gibson will oversee the development of the QAPP, QMP, and SOPs. She will ensure the implementation of all specified QA/QC procedures at the field level, the regular calibration of all field instruments and equipment as described in the QAPP and QMP, the documentation and reporting of all project field activities, and the maintenance of all chain-of-custody requirements. Dr.

Keith Levine, co-PI, will oversee the performance of all laboratory analyses in accordance with standard methods and SOPs, the implementation of all specified QA/QC procedures and protocols at the laboratory level, the regular calibration of all laboratory instruments and equipment as described in the QAPP and QMP, and the documentation and reporting of all laboratory activities.

The research team will evaluate the following qualitative and quantitative measures of success:

1. To what extent was each study hypothesis tested (fully/partially/not addressed)?
2. To what extent was each study hypothesis accepted/rejected?
3. To what extent were previously unidentified risks identified and characterized?
4. To what extent were effective technical and behavioral interventions capable of mitigating the identified risks?
5. To what extent is the risk to households in the study area using private wells better characterized by a total environment approach than by existing conventional risk assessment methods?
6. What is the burden of disease that could be avoided by implementing the identified technical and behavioral interventions?
7. What is the potential net economic benefit that could be realized by implementing the identified technical and behavioral interventions?

3. Address each of the following project elements, as applicable:

a. Collection of new/primary data. The study team will collect new data on lead and other constituents in household tap water, paint, dust, blood, and serum. Sample collection procedures are described on pp. 9-11 of the research plan. A chain-of-custody form will be attached to each sample immediately after collection. The form will indicate when the sample was collected and by whom, along with a unique participant identification number (to be kept separate from the participant's personally identifying information). The samples will be collected by personnel involved in the study and will be hand-delivered in chilled chests to the laboratories of RTI, where they will be stored at 4°C. Water samples to be analyzed for lead will be acidified at pH<= 2.0. Water, paint, dust, and soil samples will be analyzed within 30 days of collection. Blood and plasma samples will be analyzed within 48 hours of collection. Biological specimens will be handled according to standard procedures documented in the CDC's Guidelines for Safe Work Practices in Human and Animal Medical Diagnostic Laboratories. After storage, samples will be properly disposed of. Data will be analyzed as described in the research proposal using statistical functions in *R* (R Project) and model fitting algorithms in *BayesiaLab* (Chage, France).

The proposed research includes collecting two new survey data sets: (1) surveys in the 300 households participating in lead sampling to document characteristics of the child's behavior and home environment and (2) surveys of 3,500 households as part of evaluating the risk communication. The former surveys will be administered at each participating household by trained project staff. The latter surveys will be mailed to the PI's pre-existing list of 3,500 addresses in municipal extraterritorial jurisdictions of Wake County, NC. All surveys will be conducted according to the guidelines described in the Human Subjects Research Statement.

b. Use of existing/secondary data (i.e., data previously collected for other purposes or from other sources). Secondary data needed to support this work include end-of-grade testing results and other educational outcomes, juvenile complaints, early childhood blood lead screening results, and household water source for students in the study area, as described in the research proposal (pages 6-7). All secondary data sources will be documented in research outputs and models and cited in all publications arising from this work.

c. Method development. Not applicable.

d. Development or refinement of models. Multi-level regression and Bayesian network models of the effects of built, natural, and social environmental factors on blood lead levels and

children's health outcomes will be developed according to the methods described in the research plan, pp. 7-8 and p. 10. Model code will be prepared by one member of the research team and cross-checked by a second team member. Cross-validation, in which the models are fit to a "training" set and evaluated using a "testing" set, will be used to check model performance. The models and de-identified associated data will be maintained in Dr. Gibson's computing laboratory and made available upon request. Code books will be stored with each model and data set.

e. Development or operation of environmental technology. Not applicable.

f. Conducting surveys. As noted on p. 10 and p. 12 of the research plan, two surveys will be administered: household surveys to assess home environment factors and child behaviors affecting lead exposure and mail-out surveys evaluating the effectiveness of the risk communication that the project team will design. As previously noted, home environment surveys will be administered in person by research staff in 300 homes participating in lead testing. The sample size of 300 households is approximated from previous research by Ngueta et al., who used a sample size of 298 to document statistically significant ($p<0.0001$) dose-response relationship between children's blood lead and tap water lead from an aging municipal water system.[1] For the risk communication surveys, to be conservative we assume a response rate of 10%. This would result in approximately 88 respondents in each of the four treatment groups shown in Table 1 of the research plan (p. 12), for a total sample size of 352. Our preliminary research suggests that about 5% of private well owners in the target communities have tested their water for lead.[2] A response of 88 per group would provide power > 80% to detect a main effect of the risk communication design that would increase the testing rate by 5%, assuming the economic incentive has the same effect and the two interventions together increase testing to 25%. **Figure 1** shows a power analysis for the main effect of the risk communication under this scenario.

4. Data management activities. All primary data will be stored securely as described in the data management plan. All laboratory data will be stored in laboratory notebooks and electronically, with automatic backups. Data collected from individual homes will be stored on a secure computer in the PI's laboratory, subject to IRB protection procedures. Household-level data will not be made available to anyone other than the PI and graduate students working on the project, who must undergo IRB training and sign confidentiality agreements before being allowed to analyze the data. Furthermore, these data will be maintained only on the secure computer, and all analyses will be conducted on that computer only.

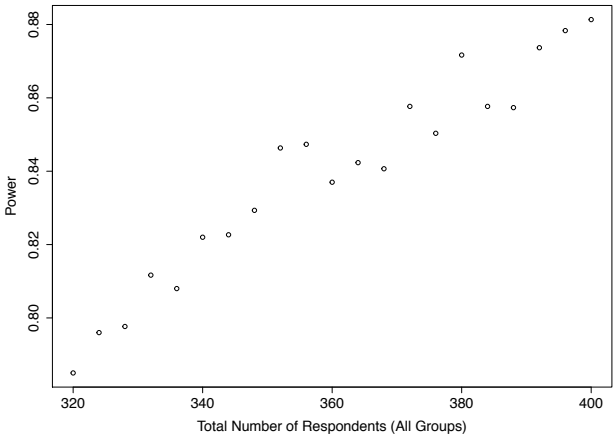

Figure 1. *The risk communication randomized controlled trial is expected to detect a 5% change in private well testing behavior with at least 80% power at a significance of 0.05, assuming at least 10% of 3,500 respond to the survey.*

References

(1) Ngueta, G.; Abdous, B.; Tardif, R.; St-Laurent, J.; Levallois, P. Use of a cumulative exposure index to estimate the impact of tap water lead concentration on blood lead levels in 1- to 5-year-old children (Montr??al, Canada). *Environ. Health Perspect.* **2016**, *124* (3), 388–395.

(2) Fizer, C. Barriers to Private Well and Septic Management: An Analysis of Homeowner Decision-Making, University of North Carolina at Chapel Hill, 2016.

Human Subjects Research Statement

1. Risks to Human Subjects

a. Human subjects involvement, characteristics, and design. Human subjects approval will be required for this project. Approval will be sought from the University of North Carolina at Chapel Hill Institutional Review Board (UNC-CH IRB) on a "just-in-time" basis after the proposal is merit-reviewed. No deception practices will be implemented in this study. UNC-CH and the project personnel will comply with all applicable provisions of EPA Regulation 40 CFR Part 26 (Protection of Human Subjects) and with EPA's procedures for oversight of the recipient's compliance with 40 CFR Part 26, as given in EPA Order 1000.17A (Policy and Procedures on Protection of Human Research Subjects in EPA Conducted or Supported Research). No human subject will be involved in this research project until the research has been approved by the EPA Human Subjects Research Review Official after review of the approval determination of the UNC-CH IRB, which has jurisdiction over this research under 40 CFR Part 26. In addition, as part of the annual report, we will provide evidence of continuing review and approval of the research by the UNC-CH IRB as required by 40 CFR 26.109(e).

We will recruit households with children under age 6 meeting the inclusion criteria specified on p. 9 of the research plan. There will be no restriction on race or gender. Minority representation will be encouraged. Because we are investigating exposures and outcomes of particular concern for young children, it is imperative that the study households have a healthy child between the ages of 1 and 6 as the focus of this research. All appropriate measures will be taken to protect this vulnerable population, as described below. This is an observational study only; the research does not involve intentional exposures.

b. Sources of materials. The proposed research involves collection of tap water and well water samples, as well as paint, dust, and soil samples from private residences of consenting households in Wake county, NC; the collection of questionnaire data from consenting adult participants; the collection of blood and plasma (biospecimens) from a child of consenting adult participants; and follow-up in the form of risk communication sent by mail to consenting participants. Collection of tap water and well water samples, as well as of paint, dust, and soil samples from private residences, and collection of biospecimens is necessary to characterize health risks and exposures faced by those in underbounded communities due to potential lead contamination of drinking water. This contamination is one risk of using unmonitored private drinking water supplies, and will be compared with risks from public drinking water systems. Such a comparison is not possible without collecting water samples from private homes. The collection of blood and plasma specimens is necessary to quantify the extent to which children in households without regulated water service are exposed to lead from drinking water and other sources, and the extent to which uptake of lead into the body occurs. The collection of paint, dust, and soil samples is necessary to quantify exposure to lead from sources other than water, to determine what fraction is attributable to drinking water. The collection of questionnaire data is necessary to determine the behavior patterns that link contamination levels to exposures.

Each individual will be given a code that is used during the study for purposes of identification while maintaining confidentiality, as described in the data management plan. Water, soil, paint, and dust samples will be collected by trained researchers (postdoctoral fellow or graduate student). All surveys will be administered in person or by mail to consenting adult respondents in accordance with all IRB guidelines. All biospecimens will be collected from the reference child of consenting respondents by a trained registered nurse (RN) or other trained medical professional at a designated collection point and will be collected in accordance with all IRB guidelines, standard medical best practices, and CDC Guidelines for Safe Work Practices in Human and Animal Medical Diagnostic

Laboratories. All risk communication messages will be drafted by a trained researcher (PI, Postdoctoral fellow or graduate researcher) and distributed to consenting adult participants via mail in accordance with all IRB guidelines.

c. Potential risks. There is a risk that information about the quality of well water or children's blood lead in participating homes could be revealed. This could pose financial difficulties if, for example, wells are found to be contaminated and the homeowner wishes to sell their home. Evidence that the well water is contaminated could reduce the value of the home. There is also a risk that educational and/or juvenile justice data about participants could be revealed. This could pose personal or financial difficulties if an individual was embarrassed by a disclosure or barred from potential employment because of it. These risks are thought to be very low, as names, addresses, and other identifiable information will be de-linked from all samples and study data, and securely stored as described in the data management plan.

There is also a risk to subjects of embarrassment in responding to household questionnaires. This risk is thought to be very low, as subjects are informed that they do not need to answer any questions they do not wish to, and questions will be designed to minimize the likelihood of embarrassment.

There are also risks associated with the donation of biospecimens to be collected by a trained registered nurse or similar health care professional. The risks of donating blood include pain, a bruise at the point where the blood is taken, redness and swelling of the vein and infection, and a rare risk of fainting. There is also an extremely rare risk of infection. These risks are thought to be extremely low, and will be mitigated through adherence to all standard medical best practices, including the CDC's Guidelines for Safe Work Practices in Human and Animal Medical Diagnostic Laboratories and WHO guidelines on drawing blood: best practices in phlebotomy. Single-use sterile supplies and standard sterile techniques will be used for all procedures, and all transport, handling, and safe disposal of biospecimens will adhere to applicable guidelines from the US Occupational Safety and Health Administration (and the Centers for Disease Control and Prevention. All other appropriate risk mitigation measures will be taken to protect study participants, medical staff, and researchers.

2. Adequacy of Projection Against Risks

a. Recruitment and informed consent. The research plan (p. 9) describes the recruitment procedure. Written, informed consent will be obtained from an adult head of household and parent or legal guardian for all participating households and children in the study, in accordance with all UNC-IRB guidelines. Upon agreeing to participate in the study subject will be asked to read and sign the consent form. When meeting the subject the first time, we will emphasize that participation is entirely voluntary. We will explain that no reprisals will be made for refusal to participate and that subjects may leave the study or refuse to participate in any part of the study at any time. We will demonstrate an informed consent form covering the following points: 1) the purpose of the study, 2) that participation is completely voluntary, no reprisals will be made for refusal to participate, and that subjects may leave the study or refuse to participate in any part of the study, 3) that he or she will be paid at the time of water sample collection and biospecimen collection, and 4) assurance that all individual data and test results will be held confidential, and that only coded summary data without personal identifiers will be released.

b. Protections against risk. Each household will be given an identification number that will be associated with all household environment specimens, biospecimens, and/or survey responses. Identifiable personal information such as names, home addresses, and contact information for participating households will be de-linked from other survey data and stored in a separate linkage file in a separate, encrypted partition of a password-protected device as described in the data management

plan. The linkage file with this contact information, showing the de-identified study participant number, will be maintained on a secure computer in the PI's laboratory. This computer is not linked to the internet and has previously been secured for storage of human subjects' information (from the PI's previous epidemiologic study in the United Arab Emirates and exposure studies in San Antonio, Texas, and Wake County, NC).

All current medical best practices to minimize discomfort associated with biospecimen collection and to ensure biosafety for participants and study personnel (i.e. all applicable infection control measures) will be strictly observed during biospecimen collection by a trained nurse, according to the applicable guidelines described above, and will be strictly observed by researchers during the handling, transport, analysis, and safe disposal of all biospecimens. These best practices will include (but are not limited to) the use of proper personal protective equipment (PPE) during sample collection, proper disinfection of all surfaces and gloves prior to biospecimen collection, the use of sterile, single-use medical supplies from established vendors for biospecimen collection, the safe and immediate disposal of all sharps, and the proper and immediate decontamination of any surfaces or areas in the unlikely event of contact with any bodily fluids. All biospecimens will be safely transported, handled, analyzed, and disposed of in accordance with applicable OSHA and CDC guidelines. These measures will ensure adequate protection of all subjects and study personnel against risks associated with biospecimen collection, transport, analysis, and disposal.

Homeowners will be informed directly if elevated levels of contaminants are found in their tap water. The research team also will recommend interventions (e.g., home water treatment).

3. Potential Benefits of the Proposed Research to Human Subjects and Others

Participants will learn about the quality of their well water. If the water is found not to meet general quality requirements of the Safe Drinking Water Act, or to pose potential health risks not covered under that act, participants will be informed about the risks and any potential interventions to address them.

In addition, participants will learn whether their children are at elevated risk of lead exposure from any household source. Early intervention can decrease the deleterious risks of lead exposure, so participants may benefit in addressing a risk that otherwise would have been undetected. Cases of elevated blood lead will be referred to the Wake County Department of Public Health for assistance.

There are substantial benefits not only to the communities that are the focus of this research but also to other underbounded communities of documenting any disparities in the quality of their drinking water, in comparison to the quality of water delivered to customers of regulated municipal water utilities.

4. Importance of the Knowledge to be Gained

This study will be the first to employ a total environment framework to systematically characterize potential disparities in drinking water quality and associated outcomes between communities that, through a legacy of segregation and racially restrictive zoning, have been denied access to municipal water and sewer service. This problem exists throughout the American South but has not been well documented to date. Similar cases of exclusion from nearby municipal water infrastructure also have been reported in other US regions, including in the Texas Lower Rio Grande River Valley and in California's Central Valley.

The PI will make every effort to minimize risks to participants by ensuring that identifiable personal information remains confidential; that appropriate measures will be taken to ensure that the collection of biospecimens is performed in a safe and sterile manner by trained health care professionals, according to medical best practices; and that any unanticipated adverse events are addressed promptly and appropriately by qualified health care professionals.

Data Management Plan

Types of Data

This interdisciplinary research will generate multiple data sets, including new environmental sampling data, household questionnaire data, biospecimen heavy metal data (both primary and existing), education data, juvenile justice (criminal) data, and survey research data. Environmental sampling data will be obtained at the level of individual households and will include trace metal analysis of tap water, soil, dust, and paint, as well as other water quality parameters (temperature, pH, conductivity, and alkalinity) and flow rates for each water sample. Household questionnaire data will include respondents' water consumption behavior, history at the current address, education level, diet, and risk mitigation measures (with respect to heavy metals in drinking water); questions about children in the home with respect to water consumption habits, diet, birth weight, and behaviors; and questions about the characteristics of the household's plumbing and private well. Primary biospecimen data will include concentrations of heavy metals in blood and plasma. Secondary biospecimen data will include blood lead concentrations. Education data will include end-of-grade exam scores, retention in grade, and learning disability status for students in the study area. Juvenile justice data will include records of juvenile complaints for children in the study area. Risk communication survey data will include information on whether the respondents have tested their well water, along with household characteristics (for example, house age, well age, and well type) and demographic information. Risk communication and mitigation data will include data on the dates and types of risk communication.

Data and Metadata Standards

All laboratory analysis data will be recorded according to standard laboratory protocols in notebooks or using laboratory reporting software and will be accompanied by the household identification number, sample type and number, date, and the name of the individual recording the results. All field data (on-site water quality analyses, flow rate data, and responses to in-person questionnaires) will be recorded using mobile survey tools (Qualtrics) according to standard field data collection protocols and will be accompanied by the date, location, time, household identification number, sample identification number (where relevant) and the name of the individual recording the results. Data for all activities will also be aggregated in a standard spreadsheet database in Excel. This database will be managed and maintained by the PI's laboratory, with use and access under the direct control of a designated analyst and database manager. Database entries will be double-checked for accuracy to prevent or correct transcription errors.

All identifiable personal data will be extracted in one or more separate linkage files containing only the identifiable personal data and an anonymous numeric identifier ("participant ID"). Linkage file(s) will be kept confidential and will be stored on an encrypted partition of a password-protected computer kept in a locked room ("secure partition") when not in use. Separate anonymized datasets will be generated prior to analysis by removing all identifiable personal data and will be stored on a separate secure partition from the linkage files. The original identifiable version of the dataset (used to generate the anonymized dataset and the linkage file) will then be destroyed using an irrecoverable file shredding program.

Study questionnaires for in-person household surveys conducted during water sample collection will be created using Qualtrics software. Surveys will be administered in person using a password-protected mobile device with device encryption. Access to surveys in Qualtrics will also be protected by a password. Once all the interviews have been conducted, data will be downloaded, anonymized,

and stored on an encrypted partition, separate from the linkage file, as described above. All files outside the secure partition that could contain any identifiable personal data will be destroyed as described above.

Risk communication surveys will be administered by mail. Returned surveys will be stored in a locked room. Each survey will be given a unique identification number. Survey responses will be entered in an Excel spreadsheet using this identification number. A linkage file containing the respondent's personally identifying information will be stored in a separate linkage file in a secure partition as previously described. Survey transcription accuracy will be checked through quality assurance by the data manager for 10% of the surveys and through checking for outliers. Paper copies of the surveys will be shredded after survey data have been recorded and cross-checked.

Provisions for Appropriate Protection of Privacy

All procedures to protect human subjects will be followed as outlined in project IRB documents. Briefly, after written and informed consent have been completed, a unique random identification number will be assigned to each participant. This code will be used in all subsequent data collection. Personally identifiable participant information will be stored in a separate, secure linkage file as previously described. Linkage files will never be shared or published, and will be kept as described above for a period of up to 5 years after publication, whereupon they will be destroyed by irrecoverable file shredding.

All analyses will be performed using a de-identified data set on an encrypted partition of a password protected computer stored in a locked room when not in use. The protected data sets will be backed up on a password protected internal server at the UNC Chapel Hill Department of Environmental Sciences and Engineering.

Policies and Provisions for Reuse and Redistribution of Data

We will never reveal any identifying information about any participant in our studies. However, we are not aware of reasons that would prohibit the sharing and re-use of final, de-identified data products. These data sets will only contain data for which identities could neither be directly or indirectly inferred. The data will be made publicly available through a link on the Web site of The Water Institute at UNC (http://waterinstitute.unc.edu/) within 1 year following completion of the project. There will be no additional restrictions or permissions required for accessing the de-identified data. Findings will be published by the researchers based on this data; the estimated dates of publication extend throughout the project period and 1 year beyond. There is an agreement regarding the right of the original data collector, creator or principal investigator for first use of the data. The specified embargo period associated with the data being submitted will extend from the projected conclusion date for initial research until one year later, to provide time for publication. The embargo will be lifted by January 1, 2021.

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BUDGET JUSTIFICATION - 2 YEARS.

Escalation: For budgeting purposes a 3% escalation per year has been applied to salaries, health insurance, and in-state tuition.

PERSONNEL:

Jacqueline MacDonald-Gibson, Principal Investigator (12% full time effort) will be responsible for overall project coordination, complying with all IRB requirements, project budgeting and reporting. She will also be responsible for statistical analysis of water, blood, dust, and paint samples for lead and for Bayesian belief network (BBN) analysis of the merged data set of household water source, childhood blood lead levels, educational achievement, and juvenile delinquency outcomes.

Mike Fisher, Postdoc (49% Year 1, 48.39% Year2). Dr. Fisher will work directly with Dr. MacDonald Gibson and the subcontactors and consultants. He/she will be co-responsible for project implementation and coordination, supervision of GRA research assistants, and participation in and coordination of data collection. Dr. Fisher will lead the profiling experiments to determine sources of lead in well water. He also will lead the evaluations of the costs and benefits of technical interventions (tap water flushing, household water treatment, and municipal infrastructure extension) to decrease lead exposure.

TBN, GRA Research Assistant (100% FTE Year 1-2) will be supervised directly by Dr. Gibson. He/she will have a lead role in recruiting participants for household water and blood sampling and for analyzing associations between water and blood lead concentrations. In addition, he/she will work under supervision of Dr. MacDonald Gibson and the subcontractors to develop a merged data set containing childhood blood lead test results from NC LEAD, educational outcomes from the NC Education Research Data Center, juvenile delinquency records from the NC Department of Juvenile Justice and Delinquency Protection, and household water source data from the Wake County Division of Revenue.

TBN, GRA Research Assistant (100% FTE Year 1, 75% FTE Year 2) will be supervised directly by Dr. MacDonald Gibson. He/she will work directly with Dr. MacDonald Gibson and subcontractors to develop risk communication materials based on the mental models approach. He/she will lead the distribution of risk communication materials and longitudinal evaluation of the impacts of these communications on private well testing and actions to prevent lead exposure. He/she also will have a lead role in data interpretation and writing of reports and manuscripts for the project as a whole.

Ron Ross (or equivalent), Water Institute Director of Finance and Administration/Project Coordinator, (2.5% FTE Year 1-2) will coordinate tracking of project progress and will assist in monitoring the project budget. He will ensure that all project reports are submitted on time.

Table 1. PERSONNEL

Position/Title	Annual Salary	% Effort on Project	Cost incl. 3% escalation
Principal Investigator	(b) (6)		
Postdoctoral Res.			
GRA Res Assist			
GRA Res Assist			
Ron Ross, Project			

Total Personnel	**$220,104**

Benefits: Effective January 1, 2017, the UNC guideline for basic benefits is to apply the estimated combined rate for the calendar year of 23.093% plus the annual hospitalization medical premium of $5,659 for full-time employees. Health insurance is escalated at a rate of 3% in the first year of the project. For postdoctoral research associates the composite rate of 8.990% plus the hospital insurance rate of $4,310.16 is applied. For graduate level research assistants, the composite rate of 8.990% plus the hospital insurance rate of $3,399.24 is applied. For temporary employees, the composite rate of 7.65% is applied. For additional information see http://research.unc.edu/offices/sponsored-research/resources/DATA_RES_OSR_INFOSHEET#fringe2

CONSULTANTS: ($12,284 Y1, $7100 Y2, total is $19,384)

1. Dr. Philip Cook of ITT/Sanford Professor Emeritus at Duke University-as of 1 July- ($10,000, $5000 Year 1 & 2 for 10 days annually at $500 per day), with his expertise in factors affecting school outcomes, will obtain school performance data for the census blocks covered by the study and will analyze the impacts of access to municipal water supplies and lead exposure on school outcomes. **2. Nurses hired through the UNC Clinical and Translational Research Center** ($64 per hour, 81 hours), total $5,184 in Y1. These nurses will draw blood for sampling from the 144 study participants. **3. Angie Brammer, editorial consultant,** ($2,100 in Years 1 and 2 for 7.5 days at $280 per day) will provide design and editorial services for the risk communication materials.

Table 2. SUPPLIES ($7,728)

Description – Sampling instruments, laptops, materials	**Cost**
1. Hanna Instruments HI98129 portable pH/conductivity meter, 3@$150 2. Spare electrodes for pH/conductivity meters, $92 3. Consumables for 3 pH/conductivity meters (calibration solutions @ $26 each, cleaning and storage solutions @ $14 each, electrode tool @ $21), total $1353 4. Sample collection bottles, 85 6 packs, total $2890 5. Laptops for GRAs; 2 13-inch MacBook Pros with 20GHZ processors/256 GB storage, $1449 each *6.* Materials for risk communication ($45)	$6,728 Yr 1, $1,000 Yr2

Table 3. TRAVEL COMPUTATION: $10,800, Year 1; , $2,750 Year 2 total $13,550

Purpose	**Location**	**Item**	**Computation**	**Cost**
Water and blood sampling	Wake County North Carolina	12 houses sampled per week for 12 weeks	120 sampling trips; Rental car per week(2 cars) = $350, miles per day/car, 200 miles; Total miles/wk, 2000, Gas per week= $250. Total per week=$600, Total for 12 weeks=$7200	$7200 Yr 1
Lead profiling in 20 households	Wake County North Carolina	Round trip travel Lead profiling by rental car (per NC mandate)	20 trips. 5 households profiled for 4 weeks, rental car/week= $175, Miles per trip=100, miles per week=500 miles, Gas per week $62.50, Total cost per week=$237.50. Total cost=$950	$950 Yr 2

Purpose	Location	Item	Computation	Cost
STAR progress review	Washington, DC	Round trip travel to DC	RT airfare: $300/person, 2 people. GSA Per diem+ M&I, $300 per person for 2 days, 2 people=$1200	$1800 Yr 1
Final results EPA STAR	Washington, DC	Round trip travel to DC	RT airfare: $300/person, 2 people. GSA Per diem+ M&I, $300 per person, 2 days, 2 people=$1200	$1800 Y2

Fees for NC Education Research Data Center (NCERDC) $24,200 (Year 1).

SHIPPING ($1,499 Year 1): Mailing of risk communications to 3,500 households.

PARTICIPATION FEES ($27,500 Yr 1, $1,000 Yr 2= $28,500)
Year 1: Each of the 300 households providing water and blood samples for analysis will receive a $75 gift card. The first 200 respondents to the risk communication survey will each receive a $25 gift card.
Year 2: $1,000. Each of the 20 households participating in intensive private well profiling will receive a $50 gift card.
TUITION ($66,947) ($32,979 in Y1, $33,968 Y2 per student): In-state tuition is a standard benefit for Graduate Research Assistants and is paid from the same source as the student's stipend. Academic Year 2017-2018 tuition is $ 5,854.50 per semester or $11,709 per academic year for MS/PhD Environmental Engineering degree programs.
SUBCONTRACTS:
1. **$54,654 (**$27,327 in Y1, $27,327 in Y2). Dr. Wandi Bruin de Bruin, PI, Leeds University, to oversee design of print risk communication and conceptual design of mobile phone risk communication in collaboration with MacDonald Gibson, using results from mental models surveys recently mailed to 1,000 households.
2. **$79,714** ($40,008 in Y1, $39,706 in Y2), Dr. Keith Levine of RTI, will analyze samples for lead concentration per our accreditation for metals in water to meet all state requirements. After the initial screening is complete, a number of sites with the highest lead concentrations will be re-sampled more intensely to achieve a lead profile.
3. $68,703 ($22,452 Year 1 & $46,251 Year 2). Dr. John MacDonald of University of Pennsylvania, will assist with planning of statistical methods for analyzing relationships among exposure to lead in drinking water in selected communities of Wake County and juvenile delinquency and criminal outcomes. University of Pennsylvania will advise on and provide oversight of regression analysis examining the effects of lead exposure in drinking water and blood lead levels on juvenile delinquency in youths and crime in young adults.
INDIRECT COSTS ($215,017): In accordance with the University's Facilities and Administration (Indirect) Cost Rate Agreement dated January 7, 2017, the rate beginning July 1, 2017 is 55.5% for sponsored research activities conducted at UNC, Chapel Hill. The base for calculating Facilities and Administrative cost (indirect cost) is modified total direct costs (MTDC), excluding equipment, capital expenditures, charges for patient care and tuition remission, long term rental costs of off-site facilities, scholarships, and fellowships as well as the portion of each sub-grant and subcontract in excess of $25,000. (See also:
http://research.unc.edu/offices/sponsored-research/resources/DATA_RES_OSR_INFOSHEET#facilities .)

Biographical Sketch

Jacqueline MacDonald Gibson

Education

Ph.D. Engineering and Public Policy, Carnegie Mellon University (2007)
Ph.D. Civil and Environmental Engineering, Carnegie Mellon University (2007)
M.S. Environmental Science in Civil Engineering, University of Illinois at Urbana-Champaign (1990)
B.A. Mathematics, Bryn Mawr College (1986)

Summary

As the principal investigator on two recent grants funded by the Robert Wood Johnson Foundation and the University of North Carolina (UNC), Dr. Gibson laid the groundwork for the proposed project by documenting racial disparities in access to municipal water supply service in North Carolina and by demonstrating the resulting disparities in environmental exposures and health outcomes. Through this research she established ties with communities facing disparities in access to water and sewer service that will facilitate recruitment for the proposed project. Dr. Gibson also has substantial prior experience in leading large field research teams, including a team of 88 researchers (22 faculty members, eight graduate students, seven post docs, and 27 research staff members at UNC, along with 24 collaborators from other institutions) for a competitively awarded study to characterize public health risks due to multiple environmental factors in the United Arab Emirates, a project that required field data collection from a randomly selected sample of 628 households. For that and other projects, she also managed all administrative needs (including staffing and budgeting), kept the projects on schedule, and produced multiple peer-reviewed publications.

Relevant Employment

Associate Professor (2014-present), **Assistant Professor** (2007-2013), Department of Environmental Sciences and Engineering, Gillings School of Global Public Health, University of North Carolina at Chapel Hill

Senior Engineer (2003-2007), **Engineer** (1999-2003), The RAND Corporation

Associate Director (1997-1999), **Senior Staff Officer** (1994-1997), **Staff Officer** (1992-1994), **Research Associate** (1990-1992), Water Science and Technology Board, U.S. National Research Council

Graduate Research Assistant (1988-1990), University of Illinois at Urbana-Champaign

Professional Service

Member, Research Triangle Environmental Health Collaborative Executive Committee (2015-2017)
Member, National Research Council Committee on Inherently Safer Chemical Processes: The Use of Methyl Isocyanate at Bayer CropScience (2011-2013)
Chair, North Carolina Director of Public Health Task Force on Health Impact Assessment (2012)
Member, World Health Organization External Consultation Committee on Environmental Health Strategy in the Eastern Mediterranean Region (2012)

Fellowships and Honors

National Institute of Environmental Health Sciences, Paper of the Month Award (2016)
IBM Junior Faculty Development Award, UNC (2014)
Newton Underwood Award for Excellence in Teaching, Department of Environmental Sciences and Engineering, UNC (2013)
Robert Wood Johnson Foundation Mentored Research Scientist Development Award (2012-2014)
Society for Risk Analysis, Best Paper Awards (2010, 2015)
National Science Foundation Graduate Research Fellowship (2003-2006)
American Water Works Association, Water Resources Division, Best Paper Award (2000)
National Research Council Individual Staff Award for Distinguished Service (1996)
University Fellowship, Avery Brundage Scholarship for Scholar-Athletes, University of Illinois at Urbana-Champaign (1988-1990)
Alumnae Regional Scholarship, Charlotte Angas Scott Prize in Mathematics, Magna Cum Laude, Bryn Mawr College (1982-1986)

Selected Relevant Peer-Reviewed Publications (from 64 total; student advisees underlined)

DeFelice, N.B., H.G. Leker, and **J. MacDonald Gibson**. In press. Annual cancer risks from chemicals in North Carolina community water systems. *Human and Ecological Risk Assessment: An International Journal.*

Stillo, F., and **J. MacDonald Gibson**. 2017. Exposure to contaminated drinking water and health disparities in North Carolina. *American Journal of Public Health* 107(1):180-185. DOI: 10.2105/AJPH.2016.303482.

DeFelice, N., J. Johnston, and **J. MacDonald Gibson**. 2016. Reducing emergency department visits for acute gastrointestinal illnesses in North Carolina (USA) by extending community water service. *Environmental Health Perspectives* 54(10):1583-1591. DOI: 10.1289/EHP160.

Naman, J., and **J. MacDonald Gibson**. 2015. Disparities in water and sewer services in North Carolina: An analysis of the decision-making process. *American Journal of Public Health* 105(10):e20-e26. DOI:10.2105/AJPH.2015.302731.

DeFelice, N., J. Johnston, and **J. MacDonald Gibson**. 2015. Acute gastrointestinal illness risks in North Carolina community water systems: A methodological comparison. *Environmental Science & Technology* 49 (16):10019–10027. DOI: 10.1021/ acs.est.5b01898.

MacDonald Gibson, J., N. DeFelice, D. Sebastian, and H. Leker. 2014. Racial disparities in access to community water supply service in Wake County, North Carolina. *Frontiers in Public Health Services and Systems Research* 3(3): article 6.

Johnston, J., and **J. MacDonald Gibson**. 2013. Screening houses for vapor intrusion risks: a multiple regression analysis approach. *Environmental Science & Technology* 47(11):5595-5602. DOI: dx.doi.org/10.1021/es4003795.

Johnston, J., and **J. MacDonald Gibson**. 2013. Quantifying spatiotemporal variability of tetrachloroethylene in indoor air due to vapor intrusion: a longitudinal, community-based approach. *Journal of Exposure Analysis and Environmental Epidemiology*. DOI: 10.1038/jes.2013.13.

MacDonald Gibson, J., J. Thomsen, F. Launay, E. Harder, and N. DeFelice. 2013. Burden of disease attributable to environmental pollution in the United Arab Emirates. *PLoS ONE* 8(3): e57536. DOI:10.1371/journal.pone.0057536. 14 pages.

Biographical Sketch

Wändi Bruine de Bruin

Education

Ph.D. Behavioral Decision Theory and Psychology, Carnegie Mellon University (1998)
M.S. Behavioral Decision Theory, Carnegie Mellon University (1997)
M.S. Cognitive Psychology, Free University Amsterdam, The Netherlands (1993)
B.S. Psychology, Free University Amsterdam, The Netherlands (1989)

Summary

Dr. Bruine de Bruin holds a University Leadership Chair in Behavioral Decision Making at the Leeds University Business School, where she also serves as the co-director of the Centre for Decision Research. She also holds affiliations with Carnegie Mellon University, the University of Southern California, and the RAND Corporation. Her research aims to understand and inform how people make decisions about their finances, health, and environmental footprint. She is a member the editorial boards of the *Journal of Experimental Psychology: Applied*, the *Journal of Behavioral Decision Making*, *Medical Decision Making*, the *Journal of Risk Research*, and *Psychology and Aging*. She is a member of the Scientific & Technical Committee of the International Risk Governance Council, which provides evidence-based advice to international policy makers, and has served on expert panels on science communication for the the U.S. National Academy of Sciences and the Council of the Canadian Academies.

Relevant Employment

Deputy Director (2016-present), Priestly International Centre on Climate; **Professor of Behavioral Decision Making** (with University Leadership Chair) (2012-present); **Co-Director** (2012-present), Centre for Decision Research; **Head**, Decision Research Subject Group (2012-present); Leeds University Business School (U.K.)

Collaborating Professor (2014-present), **Associate Professor** (2012-2014), Department of Engineering & Public Policy; **Assistant Professor** (2009-2012), Department of Engineering & Public Policy and Department of Social & Decision Sciences; **Research Faculty** (2002-2009), Department of Social & Decision Sciences; Carnegie Mellon University

Behavioral Scientist (2014-present), Center for Economic and Social Research, University of Southern California

Senior Adjunct Researcher (2012-present), The RAND Corporation

Visiting Research Scholar (2015), De Nederlandsche Bank (The Netherlands)

Visiting Professor (2013), **Visiting Research Scholar** (2007-2009), Federal Reserve Bank New York

Senior Research Consultant (2013), University of Michigan

Postdoctoral Research Fellow (1999-2002), Department of Human-Technology Interaction, Judgment and Decision Making Group, Eindhoven University of Technology (The Netherlands)

Selected Professional Service

Member, Communications Committee, Psychonomic Society (2016-present)
Editorial board, *Medical Decision Making* (2015-present), *Journal of Risk Research* (2015-present), *Psychology & Aging* (2014-present), *Journal of Experimental Psychology: Applied* (2013-present), *Journal of Behavioral Decision Making* (2010-present), *Organizational Behavior and Human Decision Processes* (2005-2007)
Advisory board member, Royal Center for Decision Making to Improve Health and Financial Independence in Old Age, University of Southern California (2014-present)
National Academy of Sciences Expert Consensus Panel on The Science of Science Communication (2015-2016)
Expert panel on the effectiveness of health risk communications, Council of the Canadian Academies (2014-2015)
Review panel on expert elicitation, U.S. Environmental Protection Agency Science Advisory Board (2009)
Member, American Council on Consumer Interests, American Geophysical Union, American Psychological Association, British Society of Gerontology, European Association for Decision Making, International Association for Research in Economic Psychology, Society for Judgment and Decision Making, Society for Risk Analysis

Selected Fellowships and Honors

Fellow, Netspar (Network for Studies on Pensions, Aging, and Retirement), The Netherlands
Fellow, Psychonomic Society
Leeds University Business School Dean's Award for Teaching Excellence (2015)
Role Model Award, Carnegie Mellon University's Sorority Women (2006)
University Research Fellowship, Eindhoven University of Technology (1999)
Finalist, Telly Awards (1999)
Outstanding Quality Award Technology Showcase (1999)

Selected Relevant Peer-Reviewed Publications (from 82 total)

Wong-Parodi, G., and **Bruine de Bruin, W.** In press. Informing public perceptions about climate change: A 'mental models' approach. *Science and Engineering Ethics.*
Canfield, C., **Bruine de Bruin, W.**, and G. Wong-Parodi, G. In press. Perceptions of electricity-use communications: effects of information, format, and individual differences. *Journal of Risk Research*
Chin, A., and **W. Bruine de Bruin**. In press. Eliciting stock market expectations: The effects of question wording on survey experience and response validity. *Journal of Behavioral Finance.*
Stone, E. R., **Bruine de Bruin, W.**, Rogers, A. M., Boker, E. M., and J. M. Gibson. In press. Designing graphs to communicate risks: Understanding how the choice of graphical format influences decision making. *Risk Analysis.*
Taylor, A.L., **Bruine de Bruin, W.**, and S. Dessai. 2014. Climate change beliefs and perceptions of weather-related changes in the United Kingdom. *Risk Analysis* 34: 1995-2004.
Bruine de Bruin, W., Stone, E. R., Gibson, J. M., Fischbeck, P. F., and M. B. Shoraka. 2013. The effect of communication design and recipients' numeracy on responses to UXO risk. *Journal of Risk Research* 16: 981-1004.
Bruine de Bruin, W., and K. G. Carman. 2012. Measuring risk perceptions: What does the excessive use of 50% mean? *Medical Decision Making* 32: 232-236.

Keith E. Levine

Biographical Sketch

Education

Ph.D. Atomic Spectrometry, Wake Forest University (1998)
B.A. Chemistry, University of Florida (1994)

Summary

Dr. Levine has nearly 20 years of experience in environmental- and health-related research under Good Laboratory Practice (GLP) conditions. In his current capacity, he is responsible for the scientific, financial, and administrative leadership of a team of 50 professional analytical scientists. His ongoing research activities are focused on development and application of analytical methods for determination of trace and ultra-trace level elements and trace element species, where he has 50 peer-reviewed publications.

Relevant Employment

Senior Research Chemist and Director, Analytical Sciences (2014-present), **Senior Research Chemist 1 and Department Manager**, TID (2011-2014), **Manager** (2006-2011), **Research Analytical Chemist 2** (2001-2006), **Research Analytical Chemist 1** (1998-2001), **Analytical Chemist 1** (1997 to 1998), RTI International

Adjunct Professor (2011-present), North Carolina Central University

Research and Teaching Assistant, **Research Technician** (1994-1998), Wake Forest University

Professional Service

Member, Society of Toxicology (2010-present)
Voting member, North Carolina Section of the American Chemical Society (ACS) Executive Committee and the Budget Committee (2003-2006, 2008-present)
Member, ACS (1997-present)
Chair, North Carolina Section of the ACS (2012)
Chair-Elect, North Carolina Section of the ACS (2011)
Chair, North Carolina Section of the Undergraduate Scholarship Committee of the ACS (2008-2011)
Alternate Councilor, North Carolina Section of the ACS (2008-2010)
Editor, newsletter of the North Carolina Section of the ACS (2003-2006)

Selected Relevant Peer-Reviewed Publications

Ericksen, K., McElroy, J., Harrington, J., **Levine, K.**, Pedersen, C., Sorensen, M., Tjonneland, A., Meliker, J., and O. Raaschou-Nielsen. 2017. Urinary cadmium and breast cancer: a prospective Danish cohort study. *Journal of the National Cancer Institute* 109 (2): 1-7.

Harrington, J., Young, D., Fry, R. C., Weber, F., Sumner, S., and **K. Levine**. 2016. Validation of a metallomics analysis of placenta tissue by inductively coupled plasma mass spectrometry. *Biological Trace Element Research* 169(2), 164-173.

Levine, K., Redmon, J., Elledge, M., Wanigasuriya, K. P., Smith, K., Munoz, B., Waduge, V. A., Periris-John, R. J., Sathiakumar, N., Harrington, J. M., Womack, D. S., and R. J. Wickremasinghe. 2016. Quest to identify geochemical risk factors associated with chronic kidney disease of unknown etiology (CKDu) in an endemic region of Sri Lanka-a multimedia laboratory analysis of biological, food, and environmental samples. *Environmental Monitoring and Assessment* 188(10), 1-16.

Vacchi-Suzzi, C., Porucznik, C. A., Cox, K. J., Zhao, Y., Ahn, H., Harrington, J. M., **Levine, K. E.**, Demple, B, Marist, C. J., Gonzalez, A., Luft, B., and J. R. Meliker. 2016. Temporal variability of urinary cadmium in spot urine samples and first morning voids. *Journal of Exposure Science and Environmental Epidemiology*.

Schwartz, G. E., Rivera, N., Lee, S.-W., Harrington, J. M., Hower, J. C., **Levine, K. E.**, Vengosh, A., and H. Hsu-Kim. 2016. Leaching potential and redox transformations of arsenic and selenium in sediment microcosms with fly ash. *Applied Geochemistry 67*: 177-185.

Vacchi-Suzzi, C., Karimi, R., Kruse, D., Silbernagel, S., **Levine, K. E.**, Rohlman, D. S., and J. Meliker. 2016. Low-level mercury, omega-3 index and neurobehavioral outcomes in an adult US coastal population. *European Journal of Medicine*, *55*(2), 699–711. DOI:10.1007/s00394-015-0890-5.

Kanu, A., **Levine, K. E.**, Haines, L. G., Massey, M., and T. Codio. 2015. Measurement of mercury levels in a commercial fish oil brand by inductively coupled plasma mass spectrometry. *The Chemical Educator* 20, 234-239.

Levine, K. E., Young, D. J., Afton, S. E., Harrington, J. M., Essader, A. S., Weber, F. X., Fernando, R. A., Thayer, K., Hatch, E. E., Robinson, V. G., and S. Waidyanatha. 2015. Development, validation, and application of an ultra-performance liquid chromatography-sector field inductively coupled plasma mass spectrometry method for simultaneous determination of six organotin compounds in human serum. *Talanta* 140, 115–121.

Harrington, J. M., D. J. Young, A. S. Essader, S. J. Sumner, and **K. E. Levine**. 2014. Analysis of human serum and whole blood for mineral content by ICP-MS and ICP-OES: Development of a mineralomics method. *Biological Trace Element Research* 160(1):132–142.

Harrington, J. M., C. M. Nelson, F. X. Weber, K. D. Bradham, **K. E. Levine**, and J. Rice. 2013. Evaluation of methods for analysis of lead in air particulates: An intra-laboratory and inter-laboratory comparison. *Environmental Science: Processes and Impacts 16*(2):256–261.

Kim, N. H., C. C. Mason, R. G. Nelson, S. E. Afton, A. S. Essader, J. E. Medlin, **K. E. Levine**, J. A. Hoppin, C. Lin, W. C. Knowler, and D. P. Sandler. 2013. Arsenic exposure and incidence of Type 2 diabetes in Southwestern American Indians. *American Journal of Epidemiology 177*(9):962–969.

Levine, K. E., C. R. Tudan, F. X. Weber, M. A. Levine, Y. S. Kim, and P. M. Grohse. 2011. Aspects of bioanalytical method validation for quantitative determination of trace elements. *Bioanalysis 3*(15):1699–1712.

Tudan, C. R., F. X. Weber, **K. E. Levine**, and P. M. Grohse. 2011. The status of trace elements in biological systems. *Bioanalysis 3*(15):1695–1697.

Collins, B. J., M. D. Stout, **K. E. Levine**, G. E. Kissling, R.L. Melnick, T. R. Fennell, J. B. Pritchard, R. Walden, K. Abdo, R. A. Fernando, L. T. Burka, and M. J. Hooth. 2011. Letter to editor: Hexavalent chromium in drinking water. *Toxicological Sciences 119*(2):425.

Levine, K. E., A. S. Essader, F. X. Weber, J. M. Perlmutter, L. S. Milstein, R. A. Fernando, M. A. Levine, B. J. Collins, and P. M. Grohse. 2007. Determination of iodine in low mass human hair samples by inductively coupled plasma mass spectrometry. *Bulletin of Environmental Contamination and Toxicology 79*(4):401–404.

Biographical Sketch

Philip J. Cook

Education

Ph.D. Economics, University of California, Berkeley (1973)
B.A. University of Michigan (1968)

Summary

Dr. Cook is ITT/Sanford Professor of Public Policy, and Professor of Economics and Sociology, at Duke University. He is a pioneer in the development and application of microeconometric methods to impact evaluation, and he published the first use of "diff in diff" evaluations of policy change using panel regression methods (1982 and 1984, with George Tauchen). Dr. Cook was elected to the National Academy of Medicine in 2001. At the moment, Dr. Cook's primary focus is the economics of crime. He is co-director of the National Bureau of Economic Research (NBER) Work Group on the Economics of Crime and co-editor of a NBER volume on crime prevention. Much of his recent research has dealt with the private role in crime prevention. He also has several projects under way in the area of truancy prevention.

Relevant Employment

Senior Associate Dean for Faculty (2009-present), Sanford School of Public Policy; **ITT/Terry Sanford Professor of Public Policy** (1994-present); **Professor of Public Policy Studies, Economics, & Sociology** (1992-present); **Professor of Public Policy and Economics** (1984-present); **Director** (1997-1999), Sanford Institute of Public Policy; **Visiting Professor** (1989-1990), Fuqua School of Business; **Director** (1985-1989), Institute of Policy Sciences and Public Affairs; **Associate Professor** (1979-1984); **Assistant Professor** (1973-1979); Duke University

Schelling Visiting Professor of Public Policy (2008-2009), University of Maryland

Resident (Sept.-Oct. 2003), Bellagio Study and Conference Center

Visiting Scholar (2000), Kennedy School of Government, Harvard University

Expert (1982, part time), Office of Policy and Management Analysis, Criminal Division, U.S. Department of Justice

Visiting Scholar (1980), Institute for Research in Social Science, University of North Carolina at Chapel Hill

Selected Professional Service

Co-director, NBER Economics of Crime Working Group (2007-present)
Member, National Research Council Committee on Deterrence and the Death Penalty (2010-2011)
Panel member, International Benchmarking Review of U.K. Sociology (2009-2010)
Member, *Crime and Justice* editorial board (2007-2010)
Vice chair, National Research Council Committee on Law and Justice (2006-2010)
Vice president, Association of Public Policy and Management (2008-2009, two years)

Member, Division Committee for the Behavioral and Social Sciences and Education, National Research Council (2001-2004)
Member, National Academy of Sciences Case Studies of School Violence Committee (2001-2002)
Consultant, Enforcement Division, U.S. Department of Treasury (1999-2000)
Chair, Department of Public Policy Studies, Duke University (1985-1989, 1997-1999)
Invited speaker, U.S. Senate Democratic Policy Council, Wilmington, Del. (1996)
Invited participant, White House Leadership Conference on Youth, Drug Use, and Violence (1996)
Director of Graduate Studies, Institute of Policy Sciences and Public Affairs, Duke University (1977-1979, 1984, 1994-1995)
Consultant, Tax Advisory Program, U.S. Department of Treasury (1994-1995)
Treasurer, Association of Public Policy Analysis and Management (1987-1994)
Director of Undergraduate Studies, Institute of Policy Sciences and Public Affairs, Duke University (1974-1975, 1992)
Member, Policy Council of the American Society of Criminology (1985-1986, 1990-1991)
Associate, Canadian Institute of Advanced Research (1986)
Member, N.C. Governor's Task Force on Drunken Driving (1982)
Chair, Graduate Curriculum Committee, Institute of Policy Sciences and Public Affairs, Duke University (1977-1979)

Selected Fellowships and Honors

Fellow of the Academy of Experimental Criminology (2012-present)
Raymond Vernon Memorial Prize for best paper in *JPAM* (2008)
Richard A. Stubbing Teacher Mentor Award, 2008
Member, Institute of Medicine, National Academy of Sciences, 2001-present
Fellow of the American Society of Criminology, 2000-present
Vernon Prize for best paper in *Journal of Policy Analysis & Management* (v. 16) (1997)
Research Associate, National Bureau of Economic Research (1996-
National Science Foundation Fellowship, 1968-1970
Special Career Fellowship, Ford Foundation (1968-1972)
National Merit Scholar (1964-1968)
Sims Award, Economics Department, University of Michigan (1967)
Phi Beta Kappa

Selected Relevant Peer-Reviewed Publications

Cook, P.J., and S. Kang. 2016. Birthdays, schooling, and crime: regression-discontinuity analysis of school performance, delinquency, dropout, and crime initiation. *American Economic Journal: Applied Economics* 8(1): 33-57.

Cook, P. J., and C. P. Durrance. 2013. The virtuous tax: lifesaving and crime-prevention effects of the 1991 federal alcohol tax. *Journal of Health Economics* 32: 261-267.

Cook, P. J., R. MacCoun, C. Muschkin, and J. Vigdor. 2008. The negative impacts of starting middle school in sixth grade. *Journal of Policy Analysis and Management* Winter: 104-121. (Winner of the Raymond Vernon Memorial Prize, 2008)

MacCoun, R., **P. J. Cook**, C. Muschkin, and J. Vigdor. 2008. Distinguishing spurious and real peer effects: evidence from artificial societies, small-group experiments, and real schoolyards. *Review of Law and Economics* 4(3): 695-714.

Biographical Sketch

John M. MacDonald

Education

Ph.D. Criminology, University of Maryland (1999)
M.A. Criminology, University of Maryland (1996)
B.A. Political Science, Vassar College (1994)

Summary

Dr. MacDonald's experience and qualifications make him especially well-suited in accomplishing the specific aims of the proposed project. He is currently a professor of criminology and sociology and a member of the executive committee of the Penn Injury Science Center. Dr. MacDonald works to improve crime and health and is recognized for his efforts to reduce violence, improve health, and enhance social justice. His work incorporates spatial and time series methods focused on evaluating the effects of changes to places or programs on people and populations. He has served in numerous leadership roles, and his work has had impact nationally, being cited by major media outlets across the globe. His work appears in the leading peer reviewed journals in criminology, economics, public health, and statistics. Research generated from Centers for Disease Control (CDC) and National Institutes of Health funded projects have appeared in the *American Journal of Epidemiology, BMJ: Injury Prevention,* the *American Journal of Preventive Medicine,* and the *American Journal of Public Health* among other outlets.

Relevant Employment

Senior Fellow, Leonard Davis Institute of Health Economics (2015-present); **Professor of Criminology and Sociology** (2015-present); **Director**, Jerry Lee Center of Criminology (2010-2015); **Associate Professor of Criminology and Sociology** (2010-2015); **Jerry Lee Assistant Professor**, Department of Criminology (2006-2010); University of Pennsylvania

Adjunct Behavioral Scientist (2010-2014), **Behavioral Scientist** (2004-2006), The RAND Corporation

Professor of Policy Analysis (2004-2006), The Pardee RAND Graduate School

Assistant Professor of Criminology, Law, and Society (2004), University of Florida

Assistant Professor of Criminology and Criminal Justice (1999-2003), **Adjunct Assistant Professor of Sociology** (2000-2003), University of South Carolina

Program Specialist (1998-1999), National Institute of Justice

Professional Service

Member, Association for Public Policy Analysis and Management (2008-present)
Member, American Society of Criminology (1994-present)
Chair, Department of Criminology, University of Pennsylvania School of Medicine (2011-2016)
Member, American Sociological Association (2000-2013)

Panel Review Group, CDC, Academic Centers for Excellence in Youth Violence Research (2010-2011)
Member, American Public Health Association (2008-2011)
Panel Review Group, Investigator Initiated Research, National Institute of Justice (2002, 2005)
Panel Review Group, Criminal Justice Drug Abuse Treatment Studies, National Institute on Drug Abuse (2001)

Fellowships and Honors

David N. Kershaw Award, Association for Public Policy Analysis and Management (2012)
Young Experimental Scholar, Academy of Experimental Criminology (2009)

Selected Relevant Peer-Reviewed Publications (from 66 total)

C. C. Branas, M. C. Kondo, S. M. Murphy, E. C. South, D. Polsky, and **J. M. MacDonald**. 2016. Urban blight remediation as a cost-beneficial solution to firearm violence. *American Journal of Public Health* 106(12): 2158-2164.

M. Chirico, R. P. Inman, C. Loeffler, **J. MacDonald**, and H. Sieg. An experimental evaluation of notification strategies to increase property tax compliance: free-riding in the City of Brotherly Love. Tax Policy and the Economy 30(1): 129-161.

Kondo, M. C., D. Keene, B. C. Hohl, **J. M. MacDonald**, and C. C. Branas. 2015. A difference-in-differences study of the effects of a new abandoned building remediation strategy on safety. *PLoS ONE* 10(7): e0129582.

MacDonald, J. 2015. Community design and crime: the impact of housing and the built environment. *Crime and Justice* 44(1): 333-383.

Branas, C. C., and **J. M. MacDonald**. 2014. A simple strategy to transform health, all over the place. Journal of Public Health Management and Practice 20(2): 157.

J. M. Anderson, **J. M. MacDonald**, R. Bluthenthal, and J. S. Ashwood. 2013. Reducing crime by shaping the built environment with zoning: an empirical study of Los Angeles. *University of Pennsylvania Law Review* 699-756.

Branas, C., R. Cheney, **J. M. MacDonald**, V. Tam, T. Jackson, and T. T. Have. 2011. A difference-in-differences analysis of health, safety, and greening vacant urban space. *American Journal of Epidemiology* 174: 1296-306

Cook, P. J., and **J. MacDonald**. 2011. Public safety through private action: an economic assessment of BIDs. *Economic Journal* 121: 445-462.

MacDonald, J. M., R. Stokes, D. Cohen, A. Kofner, and G. Ridgeway. 2010. The effect of the built environment and light rail transit on body mass index and physical activity. *American Journal of Preventive Medicine* 39: 105-112.

MacDonald, J. M., D. Golinelli, R. Stokes, and R. Bluthenthal. 2010. The effect of business improvement districts on the incidence of violent crimes. *Injury Prevention* 16: 327-332.

R. J. Stokes, **J. MacDonald**, and G. Ridgeway. 2008. Estimating the effects of light rail transit on health care costs. *Health & Place* 14(1): 45-58.

K. J. Strom and **J. M. MacDonald**. 2007. The influence of social and economic disadvantage on racial patterns in youth homicide over time. *Homicide Studies* 11(1): 50-69.

R. F. Valois, **J. M. MacDonald**, L. Bretous, M. A. Fischer, and J. W. Drane. 2002. Risk factors and behaviors associated with adolescent violence and aggression. American Journal of Health Behavior 26(6): 454-464.

Biographical Sketch

Michael B. Fisher

Education

Ph.D. Environmental Engineering, University of California, Berkeley (2011)
M.S. Environmental Engineering, Massachusetts Institute of Technology (2004)
B.A. Chemistry, Grinnell College (2002)

Summary

Dr. Fisher's primary focus for the past 10 years has been the development, monitoring, and evaluation of new and existing technologies for drinking water treatment in developed and developing country settings. Michael Fisher brings extensive experience in environmental engineering and water quality sampling and analysis, as well as relevant public health experience in study design, questionnaire development, and data analysis. His experience designing, conducting, and analyzing adequately powered field studies comparing water quality across source types and consumption patterns in rural, peri-urban, and urban settings in Ghana, Ethiopia, and Sierra Leone with funding from UK's Department for International Development, the Millennium Water Alliance, and the Conrad N. Hilton Foundation is relevant to this work. In addition, his experience on projects using both conventional and Bayesian analytical approaches to address the complex environmental, technical, organizational, and financial determinants of functionality and repair for rural wells in Ghana, with funding from the Hilton Foundation, is applicable to the current study.

Relevant Employment

Postdoctoral Researcher (2012-present), Department of Environmental Sciences and Engineering, Gillings School of Global Public Health, University of North Carolina at Chapel Hill

Visiting Researcher (2011-2012), Fundacion Cantaro Azul, La Paz, Baja California Sur, Mexico

Visiting Researcher (2009-2010), Royal College of Surgeons in Ireland

Technology Coordinator (2005-2008), HMS India

Fellowships and Honors

National Institute of Environmental Health Sciences BIOS Training Grant (2012-present)
National Science Foundation Research Fellowship (2005-2007)
National Defense Science and Engineering Grant Fellowship (2003-2004)
American Water Works Association Aquatic Research Scholarship (2003)

Selected Relevant Peer-Reviewed Publications

Fisher, M. B., Keenan, C. R., Nelson, K. L., Voelker, B. M., et al. 2008. Speeding up solar disinfection (SODIS): effects of hydrogen peroxide, temperature, pH, and copper plus ascorbate on the photoinactivation of *E. coli* in river water. *Journal of Water and Health* 6(1): 35-51.

Fisher, M. B., Love, D. C., Sheuch, R., Nelson, K. L., et al. 2011. Simulated sunlight action spectra for inactivation of MS2 and PRD1 bacteriophages in clear water. *Environmental Science and Technology*; 45(21): 9249-55

Fisher, M. B., Iriarte, M., and K. L. Nelson. 2012. Solar disinfection (SODIS) of *E. coli*, *Enterococcus*, and MS2 phage: effects of additives and alternative container materials. *Water Research* 46(6): 1745-54.

Fisher, M. B., Keane, D. A. Fernández-Ibáñez, P., Colreavy, J., Hinder, S., McGuigan, K.G., and S. Pillai. 2012. Nitrogen and copper doped solar light active TiO_2 photocatalysts for water decontamination. *Applied Catalysis B: Environmental* 130-131: 8-13.

Fisher, M. B., and K. L. Nelson. 2014. Inactivation of *Escherichia coli* by polychromatic simulated sunlight: evidence for and implications of a Fenton mechanism involving iron, hydrogen peroxide, and superoxide. *Applied and Environmental Microbiology* 80(3): 935-42.

Bartram, J., Brocklehurst, C., **Fisher, M. B.**, Luyendijk, R., Hossain, R., Wardlaw, T., and B. Gordon. 2014. Global monitoring of water supply and sanitation: history, methods and future challenges. *International Journal of Environmental Research and Public Health* 11(8): 8137-8165.

Fisher, M. B., Williams, A. R., Jalloh, M. F., Saquee, G., Bain, R. E. S., and J. K. Bartram. 2015. Microbiological and chemical quality of packaged water and household stored drinking water in Freetown, Sierra Leone. *PLOS ONE* 10(7): 241-251.

Fisher, M. B., Shields, K., Leker, H., Christenson, E., Cronk, R. D., Samani, D., Apoya , P., Lutz, A., and J. K. Bartram. 2015. Understanding handpump sustainability: determinants of rural water source functionality in the Greater Afram Plains region of Ghana. *Water Resources Research* 51(10): 8431-8449.

Williams, A. R., Bain, R. E. S., **Fisher, M. B.**, Cronk, R. D., Kelly, E. R., and J. K. Bartram. 2015. A systematic review and meta-analysis of fecal contamination and inadequate treatment of packaged water. *PLOS ONE* 10(10): e0140899.

Fisher, M. B., Mann, B. H., Cronk, R. D., Shields, K. F., Klug, T. L., and R. Ramaswamy. 2016. Evaluating mobile survey tools (MSTs) for field-level monitoring and data collection: development of a novel evaluation framework, and application to MSTs for rural water and sanitation monitoring. *International Journal of Environmental Research and Public Health* 13(9): 840.

United States
ENVIRONMENTAL PROTECTION AGENCY
Washington, DC 20460

OMB Approval No. 2030-0020
Approval Expires 06/30/17

Current and Pending Support

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Jacqueline MacDonald Gibson

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☑ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal: Elucidating Risk: From Exposure and Mechanism to Outcome-Administrative Supplement

Source of Support: NIEHS
Total Award Amount: 2,610,422.00 Total Award Period Covered: 04/01/1997 to 03/31/2017
Location of Project: University of North Carolina at Chapel Hill
Person-Months Per Year Committed to the Project. Cal: Acad: 0.45 Sumr: 0.15

Support: ☑ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal: Managing Health Risks to Wastewater Workers from Ebola and Other Emerging Pathogens: Science and Solutions (NCE)

Source of Support: NSF
Total Award Amount: 49,981.00 Total Award Period Covered: 03/01/2016 to 02/28/2018
Location of Project: University of North Carolina at Chapel Hill
Person-Months Per Year Committed to the Project. Cal: Acad: 0.00 Sumr: 0.00

Support: ☑ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal: The impact of intensive livestock production on the disease ecology of antibiotic resistant staphylococcus

Source of Support: NSF
Total Award Amount: 1,857,920.00 Total Award Period Covered: 09/15/2013 to 08/31/2018
Location of Project: University of North Carolina at Chapel Hill
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.00

Support: ☐ Current ☑ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal: A Research Roadmap for Transportation and Public Health

Source of Support: National Cooperative Highway Research Program
Total Award Amount: 250,000.00 Total Award Period Covered: 06/01/2017 to 11/30/2018
Location of Project: University of North Carolina at Chapel Hill
Person-Months Per Year Committed to the Project. Cal: Acad: 0.16 Sumr: 0.05

Support: ☐ Current ☑ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal: (b) (5) [redacted]

Source of Support: NIEHS
Total Award Amount: (b) (5) [redacted] Total Award Period Covered: 04/01/2017 to 03/31/2022
Location of Project: University of North Carolina at Chapel Hill
Person-Months Per Year Committed to the Project. Cal: Acad: 1.80 Sumr: 0.60

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

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USE ADDITIONAL SHEETS AS NECESSARY

United States
ENVIRONMENTAL PROTECTION AGENCY
Washington, DC 20460

OMB Approval No. 2030-0020
Approval Expires 06/30/17

Current and Pending Support

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Jacqueline MacDonald Gibson

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☑ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal: Elucidating Risk: From Exposure and Mechanism to Outcome-Administrative Supplement

Source of Support: NIEHS
Total Award Amount: 2,610,422.00 Total Award Period Covered: 04/01/1997 to 03/31/2017
Location of Project: University of North Carolina at Chapel Hill
Person-Months Per Year Committed to the Project. Cal: Acad: 0.45 Sumr: 0.15

Support: ☑ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal: Managing Health Risks to Wastewater Workers from Ebola and Other Emerging Pathogens: Science and Solutions (NCE)

Source of Support: NSF
Total Award Amount: 49,981.00 Total Award Period Covered: 03/01/2016 to 02/28/2018
Location of Project: University of North Carolina at Chapel Hill
Person-Months Per Year Committed to the Project. Cal: Acad: 0.00 Sumr: 0.00

Support: ☑ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal: The impact of intensive livestock production on the disease ecology of antibiotic resistant staphylococcus

Source of Support: NSF
Total Award Amount: 1,857,920.00 Total Award Period Covered: 09/15/2013 to 08/31/2018
Location of Project: University of North Carolina at Chapel Hill
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.00

Support: ☐ Current ☑ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal: (b) (5) [redacted]

Source of Support: National Cooperative Highway Research Program
Total Award Amount: (b) (5) [redacted] Total Award Period Covered: 06/01/2017 to 11/30/2018
Location of Project: University of North Carolina at Chapel Hill
Person-Months Per Year Committed to the Project. Cal: Acad: 0.16 Sumr: 0.05

Support: ☐ Current ☑ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal: (b) (5) [redacted]

Source of Support: NIEHS
Total Award Amount: (b) (5) [redacted] Total Award Period Covered: 04/01/2017 to 03/31/2022
Location of Project: University of North Carolina at Chapel Hill
Person-Months Per Year Committed to the Project. Cal: Acad: 1.80 Sumr: 0.60

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Washington, DC 20460

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Current and Pending Support

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Wandi BRUINE DE BRUIN

Other agencies (including NSF) to which this proposal has been/will be submitted.
N/A

Support: ☑ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal:
Improving decision-making competence and associated quality of life across the lifespan

Source of Support: European Union
Total Award Amount: 94,767.00 Total Award Period Covered: 09/01/2013 to 08/31/2017
Location of Project: UK
Person-Months Per Year Committed to the Project. Cal: 0.25 Acad: 0.00 Sumr: 0.00

Support: ☑ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal:
Consumer Data Research Centre

Source of Support: Economic & Social Research Council - UK
Total Award Amount: 6,561,896.00 Total Award Period Covered: 02/14/2014 to 02/13/2019
Location of Project: UK
Person-Months Per Year Committed to the Project. Cal: 0.50 Acad: 0.00 Sumr: 0.00

Support: ☑ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal:
Food Options, Opinions and Decisions (FOOD): Integrating perspectives on consumer perceptions of food safety, nutrition and waste

Source of Support: Economic & Social Research Council - UK
Total Award Amount: 37,652.00 Total Award Period Covered: 11/01/2014 to 10/31/2017
Location of Project: UK
Person-Months Per Year Committed to the Project. Cal: 0.25 Acad: 0.00 Sumr: 0.00

Support: ☑ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal:
Inequality in higher education outcomes in the UK: subjective expectations, preferences and access to information

Source of Support: Economic & Social Research Council - UK
Total Award Amount: 67,044.00 Total Award Period Covered: 04/01/2015 to 03/31/2020
Location of Project: UK
Person-Months Per Year Committed to the Project. Cal: 0.50 Acad: 0.00 Sumr: 0.00

Support: ☑ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal:
Climate and Energy Decision Making

Source of Support: National Science Foundation - US
Total Award Amount: 37,919.00 Total Award Period Covered: 09/01/2015 to 08/31/2020
Location of Project: USA
Person-Months Per Year Committed to the Project. Cal: 0.25 Acad: 0.00 Sumr: 0.00

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

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United States
ENVIRONMENTAL PROTECTION AGENCY
Washington, DC 20460

OMB Approval No. 2030-0020
Approval Expires 06/30/17

Current and Pending Support

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Wandi BRUINE DE BRUIN

Other agencies (including NSF) to which this proposal has been/will be submitted.
N/A

Support: ☑ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal:
Science and Proven Experience

Source of Support: Riksbankens Jubileumsfond (Sweden)
Total Award Amount: 281,639.00 Total Award Period Covered: 01/01/2015 to 12/31/2020
Location of Project: Sweden, USA, UK
Person-Months Per Year Committed to the Project. Cal: 0.25 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☑ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal:
Applying risk communication strategies to reduce speeding-related risks

Source of Support: European Union
Total Award Amount: 155,920.00 Total Award Period Covered: 03/13/2017 to 03/12/2019
Location of Project: UK
Person-Months Per Year Committed to the Project. Cal: 0.25 Acad: 0.00 Sumr: 0.00

Support: ☑ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal:
Engaging pension plan participants: how emotions, peer effects, and life events influence the effectiveness of pension communication

Source of Support: Tilburg University, Netherlands
Total Award Amount: 21,872.00 Total Award Period Covered: 09/01/2015 to 08/31/2018
Location of Project: UK, Netherlands
Person-Months Per Year Committed to the Project. Cal: 0.25 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☑ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal:
Testing communication strategies to save lives in emergency evacuation

Source of Support: European Union
Total Award Amount: 188,962.00 Total Award Period Covered: 01/01/2018 to 12/31/2019
Location of Project: UK
Person-Months Per Year Committed to the Project. Cal: 0.25 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☑ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal:
Using Insights from the Field Of Risk Communication to Communicate Climate Change Projections to Non-Experts

Source of Support: Economic & Social Research Council - UK
Total Award Amount: 797,264.00 Total Award Period Covered: 10/01/2017 to 09/30/2020
Location of Project: UK
Person-Months Per Year Committed to the Project. Cal: 1.25 Acad: 0.00 Sumr: 0.00

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

United States
ENVIRONMENTAL PROTECTION AGENCY
Washington, DC 20460

OMB Approval No. 2030-0020
Approval Expires 06/30/17

Current and Pending Support

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Keith Levine

Other agencies (including NSF) to which this proposal has been/will be submitted.
Not applicable.

Support: ☑ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal: HHSN273201400022C
Chemistry Support Services for the NTP

Source of Support: NIEHS
Total Award Amount: 60,000,000.00 Total Award Period Covered: 03/01/2014 to 02/28/2024
Location of Project: RTI International
Person-Months Per Year Committed to the Project. Cal: 6.00 Acad: Sumr:

Support: ☐ Current ☑ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal: 1R01ES026614-01A1
Urine Cadmium and Risk of Cardiovascular Disease

Source of Support: NIEHS
Total Award Amount: 303,345.00 Total Award Period Covered: 03/01/2017 to 11/30/2020
Location of Project: State University of New York at Stony Brook
Person-Months Per Year Committed to the Project. Cal: 1.00 Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal:

Source of Support:
Total Award Amount: Total Award Period Covered: to
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal:

Source of Support:
Total Award Amount: Total Award Period Covered: to
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal:

Source of Support:
Total Award Amount: Total Award Period Covered: to
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

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United States
ENVIRONMENTAL PROTECTION AGENCY
Washington, DC 20460

OMB Approval No. 2030-0020
Approval Expires 06/30/17

Current and Pending Support

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: John MacDonald	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☑ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal: A Randomized Trial of Abandoned Housing Remediation, Substance Abuse and Violence

Source of Support: NIH
Total Award Amount: 417,211.00 Total Award Period Covered: 04/20/2016 to 03/31/2021
Location of Project: University of Pennsylvania
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.00

Support: ☑ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal: Urban Vacant Lot Stabilization and Violence Trial

Source of Support: CDC
Total Award Amount: Total Award Period Covered: 09/01/2014 to 08/31/2019
Location of Project: University of Pennsylvania
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.00

Support: ☐ Current ☑ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal: Building Blocks for Safer Neighborhoods

Source of Support: MacArthur Foundation
Total Award Amount: Total Award Period Covered: 03/01/2017 to 03/31/2020
Location of Project: University of Pennsylvania
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal:

Source of Support:
Total Award Amount: Total Award Period Covered: to
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal:

Source of Support:
Total Award Amount: Total Award Period Covered: to
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

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Leeds University Business School

Maurice Keyworth Building
University of Leeds
Leeds LS2 9JT

W business.leeds.ac.uk

UNIVERSITY OF LEEDS

February 21, 2017

Terry Magnuson, Ph.D.
Vice Chancellor for Research
Office of Sponsored Research
The University of North Carolina at Chapel Hill
104 Airport Dr. Suite 2200, CB#1350
Chapel Hill, NC 27599-1350

Reference: ***Response to RFP number EPA-G2017-STAR-D1, entitled 'Using a Total Environment Framework (Built, Natural, Social Environments) to Assess Life-long Health Effects of Chemical Exposures', dated December 2, 2016.***

Dear Dr. Magnuson,

This letter confirms that the appropriate program and administrative personnel at ***The University of Leeds*** have reviewed the above referenced RFP and are committed to enter into a subcontract with The University of North Carolina at Chapel Hill (UNC-CH) for the performance period of 9/1/17 to 8/31/19. The work to be performed by ***The University of Leeds*** does include human research subjects. The UNC-CH Principal Investigator on this proposal is Dr. Jacqueline MacDonald Gibson. ***The University of Leeds*** does maintain an active and enforced conflict of interest policy meeting the requirements of 42 CFR Part 50, Subpart F. ***The University of Leeds's*** budget, budget justification and scope of work are provided as separate enclosures to this letter. The estimated cost of the proposed subcontract will not exceed **$ 54,655** and includes appropriate direct and indirect costs. Furthermore, by submission of this commitment letter ***The University of Leeds*** and its Principal Investigator (PI) certify (1) that the information submitted within the application is true, complete and accurate to the best of ***The University of Leeds*** and PI 's knowledge; (2) that any false, fictitious, or fraudulent statements or claims may subject ***The University of Leeds*** and PI to criminal, civil, or administrative penalties; and (3) that the PI agrees to accept responsibility for the scientific conduct of the project and to provide the required progress reports if an award is made as a result of UNC-CH's application. If you have any questions, please contact the undersigned at w.bruinedebruin@leeds.ac.uk

Sincerely,

Signature of Authorized Organization Official
Mrs. Sarah Shaw
Faculty Research & Innovation Manager

Wandi Bruine de Bruin

Signature of Principal Investigator -
Professor W. Bruine de Bruin

Enclosed:
Budget
Budget Justification
Scope of Work

February 22, 2017

Dr. Jacqueline MacDonald Gibson, Associate Professor
Department of Environmental Sciences and Engineering
Gillings School of Global Public Health
Michael Hooker Research Center 0032
UNC Campus Box 7431
Chapel Hill, NC 27599-7431

Reference: EPA STAR Grant Analytic Support

Dear Dr. Gibson,

RTI International (DUNS 004868105) is pleased to confirm our commitment to serve as a subcontractor in support of your EPA STAR Grant application. RTI proposes to perform our portion of the services over a performance period of twenty four (24) months commencing on or about September 1, 2017 for fixed price amount of $79,714. In support of this offer we include our budget proposal for your review. If UNC's application is selected for award by EPA, we would be pleased to authorize our portion of the effort under a subcontract containing mutually agreeable terms and conditions as well as any necessary EPA flow-down provisions. This offer shall remain firm for a period of 270 days from your receipt. RTI appreciates the opportunity to submit this proposal. If you have any questions, please contact me at 919-316-3194 or by email at dfaucette.Contractor@rti.org.

Sincerely,

David H. Faucette

David H. Faucette
Office of Contracts
RTI International
EIN: 56-0686338

[RTI Proposal No. 0281700.710]

February 21, 2017

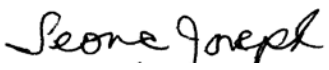
Terry Magnuson, Ph.D.
Vice Chancellor for Research
Office of Sponsored Research
The University of North Carolina at Chapel Hill
104 Airport Dr. Suite 2200, CB#1350
Chapel Hill, NC 27599-1350

Reference: ***Response to solicitation/RFP/RFA number EPA-G2017-STAR-D1, entitled Using a Total Environment Framework to Assess Life-Long Health Effects of Chemical Exposures***

Dear Dr. Magnuson**,**

This letter confirms that the appropriate program and administrative personnel at the Trustees of the University of Pennsylvania have reviewed the above referenced Solicitation/RFP/RFA and are committed to enter into a subcontract with The University of North Carolina at Chapel Hill (UNC-CH) for the performance period of 9/1/2017 to 8/31/2019. The work to be performed by ***The University of Pennsylvania*** does not include animal and/or human research subjects. The UNC-CH Principal Investigator on this proposal is Dr. John MacDonald. The University of Pennsylvania does maintain an active and enforced conflict of interest policy meeting the requirements of 42 CFR Part 50, Subpart F. The University of Pennsylvania's budget, budget justification and scope of work are provided as separate enclosures to this letter. The estimated cost of the proposed subcontract will not exceed $68,703 and includes appropriate direct and indirect costs. Furthermore, by submission of this commitment letter The University of Pennsylvania and its Principal Investigator, Dr. John MacDonald certify (1) that the information submitted within the application is true, complete and accurate to the best of the University's and PI's knowledge; (2) that any false, fictitious, or fraudulent statements or claims may subject the ***University*** and PI to criminal, civil, or administrative penalties; and (3) that the PI agrees to accept responsibility for the scientific conduct of the project and to provide the required progress reports if an award is made as a result of UNC-CH's application. If you have any questions, please contact the undersigned at cljoseph@upenn.edu**.**

Sincerely,



Signature of Authorized Organization Official
Leona Joseph, M.A., Ed., CRA

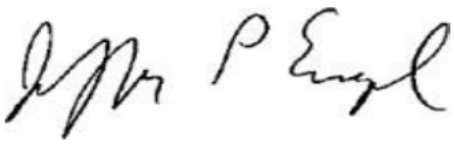
Signature of Principal Investigator

February 16, 2017

Dear Review Panel:

I am writing to express my support for a proposal submitted to EPA's STAR program entitled "Building US Water Infrastructure to Improve Childhood Outcomes," with Dr. Jacqueline MacDonald Gibson as the Principal Investigator. I served as the North Carolina State Health Director from 2009-2012. During my service, I received anecdotal reports of racial disparities in the provision of water supply and sanitation services in our state. These reports suggested that some African American communities on the edges of cities and towns (or even encircled by those cities and towns) lack access to nearby water, sewer, trash collection, and other municipal services. However, whether these anecdotal reports represented a larger phenomenon and whether there were resulting effects on exposure to contaminants in drinking water was unknown. I asked Dr. MacDonald Gibson to study the public health significance of this problem. Under my mentorship, she was awarded a Robert Wood Johnson Foundation grant to support this research. Her research uncovered a statistically significant association between race and access to municipal water services in peri-urban areas. Subsequently, she found an increased risk of microbial contaminants in drinking water in these communities and an associated increased incidence of emergency department visits for acute gastrointestinal illness. Recently, her preliminary data suggest that residents of these communities also could face a risk of exposure to lead in drinking water comparable to the exposures in Flint, Michigan. As a former state health director, I strongly believe that Dr. MacDonald Gibson's preliminary findings about lead exposure warrant substantial additional investigation.

Sincerely,



Jeffrey P. Engel, M.D.
Executive Director

Duke | CENTER for CHILD and FAMILY POLICY

Bridging the gap between research and public policy
to improve the lives of children and families

Dr. Jacqueline MacDonald Gibson
Associate Professor, Department of Environmental Sciences and Engineering
Gillings School of Global Public Health
University of North Carolina, Chapel Hill
Michael Hooker Research Center 0032
Campus Box 7431
Chapel Hill, NC 27599-7431

February 21, 2017

Dear Dr. Gibson:

As Director of the North Carolina Education Research Data Center (NCERDC), I am pleased to support the grant application for your study entitled "Building US Water Infrastructure to Improve Childhood Outcomes: Interventions to Decrease Childhood Lead Exposure from Private Wells" in response to the request for proposals entitled "Using a Total Environment (Built, Natural, Social Environments) to Assess Life-long Health Effects of Chemical Exposures" issued by the U.S. Environmental Protection Agency. I understand that the goal of this research is to assess the effects of lead exposure in drinking water and exclusion from municipal water supply services on childhood outcomes, including educational outcomes. Should the study be funded and upon completion of the NCERDC Data Use Agreement, we will provide the project team with the information required on Wake County students and schools for the study period from January 1, 1995, through December 31, 2016. These data will include math and reading EOG results for grades 3-8, gender, race, parents' level of education and economic disadvantage, school, test date, age on test date, and other relevant information as requested. NCERDC will match individual students to an address list of study areas that you will provide to us. In addition, you will provide NCERDC with a data security plan and documentation of IRB approval from the University of North Carolina, Chapel Hill, along with other documentation required by NCERDC. The total estimated cost for NCERDC to match your student address data to NCERDC files and prepare geocoded data files for your project is $22,100, equivalent to 20 days of data center services at a rate of $1,105 per day. This fee covers cleaning and formatting of the student address file, the matching and verification process, and related documentation. In addition, the NCERDC standard data access fee will apply: $2,100, equivalent to 2 days of data center services. This fee covers administrative costs of proposal review, access to existing NCERDC files and documentation, and some technical assistance.

I look forward to NCERDC's support of your research.

Sincerely,

Clara G. Muschkin, Ph.D.
Director, North Carolina Education Research Data Center
Associate Research Professor of Public Policy
Duke University

DEPARTMENT OF HEALTH AND HUMAN SERVICES
DIVISION OF PUBLIC HEALTH

ROY COOPER
GOVERNOR

MANDY COHEN, MD, MPH
SECRETARY

DANIEL STALEY
DIRECTOR

February 24, 2017

To Whom It May Concern:

I am pleased to write this letter in support of Dr. Jacqueline MacDonald Gibson's proposal for a study entitled "Building US Water Infrastructure to Improve Childhood Outcomes: Interventions to Decrease Childhood Lead Exposure from Private Wells." This project addresses long-held concerns in the NC Division of Public Health about the effects on children's health of exposure to contaminants in private drinking water wells.

In support of this project, the NC Division of Public Health, Childhood Lead Poisoning Prevention Program is able to provide Dr. Gibson with data maintained in our surveillance system (NC LEAD). The information to be provided will include the results of all childhood blood lead surveillance test results collected in Wake County from January 1, 1995, through December 31, 2016. The data set will include child name, birth date, test date, blood lead level, type of test (venous or capillary), and home address. The provision of these data is contingent upon a data sharing agreement between NC Childhood Lead Poisoning Prevention Program and Dr. Gibson ensuring appropriate measures are in place for protecting confidentiality. In addition, Dr. Gibson will obtain IRB approval for the proposed research through the University of North Carolina.

The results of Dr. Gibson's research will help the Childhood Lead Poisoning Prevention Program in targeting our program resources to improve the protection of children's health in North Carolina. I look forward to receiving the results of this vitally important research.

Sincerely,

Ed Norman, Program Manager
NC Childhood Lead Poisoning Prevention Program

WWW.NCDHHS.GOV
TEL 919-707-5854 • FAX 919-845-3972
LOCATION: 5605 SIX FORKS RD • RALEIGH, NC 27609
MAILING ADDRESS: 1632 MAIL SERVICE CENTER • RALEIGH, NC 27699-1632
AN EQUAL OPPORTUNITY / AFFIRMATIVE ACTION EMPLOYER

North Carolina Department of Health and Human Services
Division of Public Health

Roy Cooper
Governor

Mandy Cohen
Secretary

Daniel Staley
Division Director

February 10, 2017

Dr. Jacqueline MacDonald Gibson
Associate Professor, Department of Environmental Sciences, and Engineering
Gillings School of Global Public Health
University of North Carolina, Chapel Hill
Michael Hooker Research Center 0032
Campus Box 7431
Chapel Hill, NC 27599-7431

Dear Dr. MacDonald Gibson,

Occupational and Environmental Epidemiology Branch (OEEB) is pleased to write this letter of support for the application to the Environmental Protection Agency Science To Achieve Results (ST AR) grant. OEEB is the branch of public health that deals with environmental and occupational conditions and hazards that may pose a risk to human health. OEEB identifies and quantifies exposures to environmental and occupational contaminants; conducts risk assessments and risk communication; provides medical evaluation and surveillance for adverse health effects; and provides health-based guidance on levels of exposure to such contaminants. OEEB is excited about the new collaboration with you and your colleagues to investigate childhood lead exposure through in private well water. Our branch will provide direct partnership efforts to help develop and test behavioral interventions on lead in private well water. The efforts undertaken in this grant will expand our efforts through our partnership and complement the work of Occupational and Environmental Epidemiology Branch to increase education and outreach on lead and private well water issues. OEEB commits to this new partnership and opportunities this grant funding will provide to the citizens of North Carolina.

Mina Shehee, PhD
Head, OEEB

www.ncdhhs.gov
Tel 919-707-5900 • Fax 919-870-4807
Location: 5505Six Forks Road • Raleigh, NC 27609
Mailing Address: 1912 Mail Service Center • Raleigh, NC 27699-1912
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OMB Approval No. 4040-0006

BUDGET INFORMATION - Non-Construction Programs

SECTION A - BUDGET SUMMARY

Grant Program Function or Activity (a)	Catalog of Federal Domestic Assistance Number (b)	Estimated Unobligated Funds		New or Revised Budget		
		Federal (c)	Non-Federal (d)	Federal (e)	Non-Federal (f)	Total (g)
1. Year 1	66.509			$466,527.00		$466,527.00
2. Year 2	66.509			$333,473.00		$333,473.00
3.						$0.00
4.						$0.00
5. Totals				$800,000.00		$800,000.00

SECTION B - BUDGET CATEGORIES

6. Object Class Categories	GRANT PROGRAM, FUNCTION OR ACTIVITY				Total (5)
	(1) Year 1	(2) Year 2	(3)	(4)	
a. Personnel	[redacted]				
b. Fringe Benefits					
c. Travel					
d. Equipment					
e. Supplies	$6,728.00	$1,000.00			$7,728.00
f. Contractual	$89,787.00	$113,284.00			$203,071.00
g. Construction					
h. Other	$98,462.00	$42,068.00			$140,530.00
i. Total Direct Charges (*sum of 6a-6h*)	$317,975.00	$267,008.00			$584,983.00
j. Indirect Charges	$148,552.00	$66,465.00			$215,017.00
k. TOTALS (*sum of 6i and 6j*)	$466,527.00	$333,473.00			$800,000.00
7. Program Income					

Standard From 424A (Rev. 7-97)
Prescribed by OMB Circular A-102

SECTION C - NON-FEDERAL RESOURCES					
(a) Grant Program		(b) Applicant	(c) State	(d) Other Sources	(e) TOTALS
12. TOTAL (sum of lines 8-11)					
SECTION D - FORECASTED CASH NEEDS					
13. Federal	**Total for 1st Year**	**1st Quarter**	**2nd Quarter**	**3rd Quarter**	**4th Quarter**
14. Non-Federal					
15. TOTAL (*sum of lines 13 and 14*)					
SECTION E - BUDGET ESTIMATES OF FEDERAL FUNDS NEEDED FOR BALANCE OF THE PROJECT					
(a) Grant Program		FUTURE FUNDING PERIODS (Years)			
		(b) First	(c) Second	(d) Third	(e) Fourth
20. TOTAL (*sum of lines 16-19*)					
SECTION F - OTHER BUDGET INFORMATION					
21. Direct Charges:			22. Indirect Charges:		
23. Remarks:					

Standard Form 424A (rev. 7-97) Page 2

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Proposal Summary

Proposal Number: **Proposal Status:**
Sponsor Deadline: 03/02/2017 **Submission Method:**
Submission Type: Application

INVESTIGATOR DATA

PROJECT DIRECTOR / PRINCIPAL INVESTIGATOR CONTACT INFORMATION

Prefix:	**First Name:**	**Middle Name:**	**Last Name:**	**Suffix:**
	Jacqueline		MacDonald Gibson	

Position/Title:	Associate Professor	**Organization:**	University of North Carolina at Chapel Hill
Department:	Environmental Sciences and Eng	**Division:**	
Street1:	135 Dauer Drive	**Street2:**	148A Rosenau Hall, Campus Box 7431
City:	Chapel Hill	**County:**	Orange
State:	NC	**Zip Code:**	27599-1350
Country:	USA	**Employee ID:**	
Phone:	919-966-7892	**Fax:**	919-966-7911
Email:	jackie.macdonald@unc.edu		

First Budget Period Effort: **Calendar:** **Academic:** **Summer:**

Status of PI:
Status Waiver Required?
Signed Intellectual Property Waiver Attached?
Signed Conflict of Interest Disclosure Attached?
Agency Certification Documentation Attached?
Cost Sharing Authorization Form Attached?

SPONSOR DATA

Agency: Environmental Protection Agency
Proposal Type
Sponsor Mechanism: Using a Total Environment Framework (Built, Natural, Social Environments) to Assess Life-long Health Effects of Chemical Exposures
Sponsor Type:
Sponsor Code:
Sponsor Name:
SubDivision 1:
SubDivision 2:

PROJECT DATA

Title of Project: Building US Water Infrastructure to Improve Childhood Outcomes Interventions to Decrease Childhood Lead Exposure from Private Wells
Is This a Subcontract?
If Yes, who is prime?
Type of Proposal:
Type of Agency:
Kind of Application:
Previous Grant # or Federal Identifier:
Change in grantee institution? No
Type of Project:

PROJECT ADMINISTRATION

Who is responsible for this research?

Departmental Identification Number:	**Primary:**	**Secondary:**
Departmental Name:	**Primary:**	**Secondary:**
Primary Dept. Contact Info:		
Account Classification:	**Primary:**	**Secondary:**

Other Institutional Code:
NAICS Code:

COMPLIANCE DATA

Are animal subjects used?
Is IACUC review pending?
IACUC Protocol #
IACUC Approval Date:
Are human subjects used?
Is IRB review pending?
IRB Protocol #
IRB Approval Date:
Does this project involve use of any of the following? Radioactive Material(s), Radiation Producing Devices(s), Recombinant DNA, Biohazardous Chemical(s), Class IIIb or IV Lasers, Other certifications of health, safety and/or environmental compliance.

BUDGET DATA

Performance Dates	**Begin Date**	**End Date**
First Budget Period:		
Cumulative Budget Period:		

Cost Sharing Information	**Mandatory**	**Voluntary**
Committed:		
Amount:		
Source:		

Budget Period Total:	**Direct Cost**	**Indirect Cost**	**Total Cost**

AWARD DATA

Award #: **Contract #:** **Date:**

Budget Period Total:	**Direct Cost**	**Indirect Cost**	**Total Cost**

EXPORT CONTROL

1. Will the project involve participation, collaboration or access to information by foreign nationals, defined as: individuals with foreign citizenship, foreign governments, foreign associations and corporations, or foreign political parties? Note: Foreign nationals granted US citizenship, or permanent residence "green card" or granted status as a "protected individual", e.g., political refugees and political asylum holders are "EXEMPT" from deemed export rule.
2. Will the project involve the shipment of equipment, technology, software, materials data or other information?
3. Will the project involve a foreign subcontract or other foreign contractual agreement?

COMMENTS AND EXPLANATIONS

PLEASE INDICATE ANY SPECIAL INSTRUCTIONS BELOW:

BUDGET INFORMATION - Non-Construction Programs

OMB Number: 4040-0006
Expiration Date: 01/31/2019

SECTION A - BUDGET SUMMARY

Grant Program Function or Activity (a)	Catalog of Federal Domestic Assistance Number (b)	Estimated Unobligated Funds		New or Revised Budget		
		Federal (c)	Non-Federal (d)	Federal (e)	Non-Federal (f)	Total (g)
1. Year 1	66.509	$	$	$ 466,527.00	$	$ 466,527.00
2. Year 2	66.509			333,473.00		333,473.00
3.						
4.						
5. Totals		$	$	$ 800,000.00	$	$ 800,000.00

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Prescribed by OMB (Circular A -102) Page 1

SECTION B - BUDGET CATEGORIES

6. Object Class Categories	GRANT PROGRAM, FUNCTION OR ACTIVITY (1) Year 1	(2) Year 2	(3)	(4)	Total (5)
a. Personnel	$				
b. Fringe Benefits					
c. Travel					
d. Equipment					
e. Supplies	6,728.00	1,000.00			7,728.00
f. Contractual	89,787.00	113,284.00			203,071.00
g. Construction					
h. Other	98,462.00	42,068.00			140,530.00
i. Total Direct Charges (sum of 6a-6h)	317,975.00	267,008.00			$ 584,983.00
j. Indirect Charges	148,552.00	66,465.00			$ 215,017.00
k. TOTALS (sum of 6i and 6j)	$ 466,527.00	$ 333,473.00	$	$	$ 800,000.00
7. Program Income	$	$	$	$	$

[redacted]

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Prescribed by OMB (Circular A -102) Page 1A

SECTION C - NON-FEDERAL RESOURCES

(a) Grant Program	(b) Applicant	(c) State	(d) Other Sources	(e)TOTALS
8.	$	$	$	$
9.				
10.				
11.				
12. TOTAL (sum of lines 8-11)	$	$	$	$

SECTION D - FORECASTED CASH NEEDS

	Total for 1st Year	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
13. Federal	$	$	$	$	$
14. Non-Federal	$				
15. TOTAL (sum of lines 13 and 14)	$	$	$	$	$

SECTION E - BUDGET ESTIMATES OF FEDERAL FUNDS NEEDED FOR BALANCE OF THE PROJECT

(a) Grant Program	FUTURE FUNDING PERIODS (YEARS)			
	(b)First	(c) Second	(d) Third	(e) Fourth
16.	$	$	$	$
17.				
18.				
19.				
20. TOTAL (sum of lines 16 - 19)	$	$	$	$

SECTION F - OTHER BUDGET INFORMATION

21. Direct Charges:

22. Indirect Charges:

23. Remarks:

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